(2)

Mapping, Charting, and Geodesy Division Abstracts of Publications, Presentations, and Transitions 1991

Michael M. Harris
Janice M. Garner
Mapping, Charting, and Geodesy Division
Ocean Science Directorate

May 1992

ADPUB 002-92

CONTENTS

MC&G DIVISION
PUBLICATION LIST
1991

JOURNAL ARTICLES:

Bourgeois, B., M. Harris, P. Wischow, J. Ross, A. Martinez, P. Duvoisin, and H. Barad, "Design of the Geophysical Airborne Survey System: A Distributed Microprocessor Application, ISMM Microcomputer Applications, April 1991.

Bourgeois, B., J. Ross, and W. Avera, "High Accuracy Magnetic Measurements with the ASQ-81 Scalar Magnetometer". IEEE.Transactions on Instrumentation and Measurements, August 1991.

Estep, L., Eigenanalysis of Bottom Reflectance Spectra, The Hydrographic Journal, October 1991.

Estep L., J. Holloway, Estimators of Bottom Reflectance Spectra, International Journal of Remote Sensing, April 1991.

NOARL BOOK CONTRIBUTIONS:

McLeod, M. G., Geomagnetic Jerks and Temporal Variation, Encyclopedia of Earth System Science, Vol. 2., Academic Press, San Diego, September 1991.

NOARL REPORTS:

Nicolaides, T., G. McCardle, M. Thiele, W. Avera, J. Ross, Accuracy Improvements in the Application of the Ring-Core Fluxgate Magnetometer, NOARL Report 12, January 1991.

Kalcic, M.T., S.C. Lingsch, Multispectral Software Development for the Airborne Bathymetric Survey System, NOARL Report 17, May 1991.

NOARL TECHNICAL NOTES:

Avera, W., E. Mozley, Surveillance with Deployable Distributed Systems and the Impact of Electromagnetic Noise Sources, NTN 181, October 1991.

Fraley, D., W. Avera, T. Kooney, J. Reynaud, Underwater Magnetic Signature Measuring System (MAGMES) Volumes 1 & 2, NTN 169.

Lohrenz, M. C., P. Wischow, M. Trenchard, L. Riedlinger, H. Rosche, S. Briggs, CAC #CD-1991-A-MAP3-10004 (Northern Pacific Ocean at a Scale of 1:500,000 Scale) NTN 117, March 1991.

Lohrenz, M. C., P. Wischow, M. Trenchard, L. Riedlinger, M. Mehaffey, J. Johnson, S. Tyskiewicz, J. Kaufman, M. Gendron, S. Myrick, H. Rosche III. CAC #CD-1992-A-MAP5-10008 (Africa, Eurasia and Australia at Scale of 1:2,000,000). NTN 202, December 1991.

Miller, H.V., T. Green-Douglas, C.L. Walker, R.K. Clark, T.H. Fay, Multispectral Bathymetry Programs: A Users Guide, NTN 95.

Myrick, S., M. Lohrenz, Data Base Design Document for the Digital Map Computer Software in the A-12 Digital Map Set, NTN 162.

Myrick, S., M. Lohrenz, P. Wischow, M. Trenchard, S. Tyskiewicz, J. Kaufman, MDFF HELP: Library: On-Line Documentation for the Map Data Formatting Facility, NTN 211.

Myrick, S., et al., CAC #CD-1991-A-MAP2-10007 (W. U.S. at 1:250K Scale), NTN 192, October 1991.

Riedlinger, L., H. Rosche, S. Briggs, M. Lohrenz, P. Wischow, M. Trenchard, CAC #CD-1991-A-MAP3-10006, (Unknown area and scale) NTN 140, July 1991.

Riedlinger, L., H. Rosche III, et al., CAC #CD-1991-A-MAP3-10003 (W. Pacific Rim at 1:500,000 Scale), NTN 98, February 1991.

Rosche, H., et al., CAC CD-1991-B-MAP3-10001 (Update of CD-1990-A-MAP3-00001), NTN 107, March 1991.

Rosche, H., et al., CAC CD-1991-D-MAP3-10000 (Prototype CAC with NOARL compression, using 1/1 method of generating codebooks; scale of 1:500K; isolated areas around the globe), NTN 200, November 1991.

Shaw, K., D. Byman, S. Carter, M. Kalcic, M. Clawson, M. Harris, A Summary of the Collected Data from a Survey of Navy Digital MC&G Requirements, NTN 197, November 1991.

Trenchard, M., L. Riedlinger, H. Rosche, S. Briggs, M. Lohrenz, Wischow, CAC #CD-1991-A-MAP3-10002 (Update of CD-1990-A-MAP-0002) NTN 139, May 1991.

Wischow, P., M. Trenchard, L. Riedlinger, H. Rosche, S. Briggs, M. Lohrenz, CAC #CD-1991-A-MAP3-10005 Mediterranean at 1:5000,000 scale, NTN 119, April 1991.

SPECIAL PROJECTS:

Carter, S., The DHI Perspective, Vol. 1, Summer 1991.

Carter, S.V., Winter 1991, Scientific and Technical Information for the Naval Digital MC&G Interest Group, "DMAP News".

Lohrenz, M. C., Military Specification: The Navy Standard Compressed Aeronautical Chart (CAC) Database, Special Project #SP 024:351:91, August 1991.

Mozley, E., T. Kooney, D. Byman, D. Fraley, Kings Bay Airborne Electromagnetic Survey. Submitted as Special Project for sponsor.

Walker, C., M. Kalcic, B. Ray, Multispectral Imagery Support for Location of Hazards to Navigation. Report for the Naval Oceanographic Office, May 3, 1991.

PROCEEDINGS:

Arnone, R., G. Terrie, R. Oriol, Coupling Surface Chlorophyll and Solar Irradiance in the North Atlantic. MTS 91, New Orleans, LA, November 11-13, 1991.

Avera, W., D. Fraley, J. Reynaud, D. Byman, R. Burgett, A New Ocean Bottom Magnetometer System for Continental Shelf Measurements. MTS 91, New Orleans, LA, November 11-13, 1991.

Bourgeois, B., C. Walker, Neural Network Seafloor Characterization from Sidescan Sonar Imagery. MTS 91, New Orleans, LA, November 11-13, 1991.

Bourgeois, B., C.Walker, Sidescan Sonar Image Interpretation with Neural Networks. IEEE 1991 Oceans Conference, Hawaii, October 1-3, 1991.

Bourgeois, B., A. Martinez, "Nonlinear Phenomena in Adaptive LMS Filter Signals". 1991 IEEE Southeast Conference, Williamsburg, VA, April 1991.

Bourgeois, B., C. Walker, Texture Estimation with Neural Networks. IEEE Conference on Neural Networks for Ocean Engineering, Washington, DC, August, 1991.

Breckenridge, J., Issues of Data Content and Structure Requirements for Spacially Oriented Oceanographic/Hydrographic Feature Data. GIS/LIS, Atlanta, GA, November 1, 1991.

Estep, L., R. Arnone, Impact on the Medium MTF by Model Estimation of b, SPIE, San Diego, July 21-26, 1991.

Estep, L., J. Kaufman, Beam and Diffuse Optical Coefficients from Laser Backscatter: Theory and Experiment. IGARSS '91, Espoo, Finland, June 3-6, 1991.

Fay, T., V. Miller, An Automatic General Purpose Linear Feature Extractor for Digital Multispectral Imagery. MTS 91, New Orleans, LA, November 11-13, 1991.

Hsu, L., Coupling Regional and Global Tide Models. MTS 91, New Orleans, LA, November 11-13, 1991.

Hsu, L., J. Lewis, Open Boundary Conditions for a Coastal Tide Model, EOS Tran. AGU, April 1991.

Lohrenz, M. C., H. Rosche III, M. E. Trenchard, Compression of Scanned Aeronautical Chart Data in Support to Naval Aircraft Digital Moving Map Systems. IEEE Data Compression Conference, Navy Special Session, Snowbird, UT, April 8-11, 1991.

McLeod, M. G., External Source Fields in Magnetic Observatory Annual Means, Twentieth General Assembly of the IUGG, Vienna, Austria, 11-24 August, 1991.

Mozley, E., T. Kooney, D. Byman, Advanced Airborne Electromagnetic Hydrography. MTS 91, New Orleans, LA, November 11-13, 1991.

Mozley, E., Airborne Electromagnetic Hydrographic Survey Technology. SEG, Houston, TX, November 14, 1991.

Mozley, E.C., T. Kooney, D. Byman, and D. Fraley, Airborne Electromagnetic Hydrographic Survey Technology. SEG, May 23, 1991.

Rosche, H., Back Propagation Neural Networks for Bathymetry Modeling Using Multispectral Data. U.S. DECUS Spring Atlanta Symposium, Atlanta, GA, May 6-10, 1991.

Rosche, H., Image Color Reduction and Its Applications to Digital Data. U.S. DECUS 1991 Spring Atlanta Symposium, May 6-10, 1991, Atlanta, GA.

Rosche, H., M. Lohrenz, M. Trenchard, Digital Data Compression Using Vector Quantization and Double Color Space Normalization. IEEE Data Compression Conference, Snowbird, UT April 8-11, 1991.

Shaw, K., D. Byman, S. Carter, M. Harris, M. Kalcic, M. Clawson, An Analysis of Navy Digital MC&G Requirements. DoD MC&G Conference, Washington DC, October 1991.

Terrie, G., R. Arnone, R. Oriol, Variability of the Solar Irradiance at the Ocean Surface. MTS 91, New Orleans, LA, November 11-13, 1991.

Trenchard, M.E., M.C. Lohrenz, Digital Map Products In Support of Avionic Display Systems, 1991 SPIE/SPSE SYMPOSIUM ON ELECTRONIC IMAGING, SCIENCE AND TECHNOLOGY San Jose, CA, 24 February - 1 March 1991.

Walker, C., Effects of Finite Spectral Bandwidth in Multispectral Optical Bathymetry. MTS 91, New Orleans, LA, November 11-13, 1991.

Wischow, P., M. Lohrenz, M. Trenchard, The Application of NOARL's Aeronautical Chart Compression Techniques to Nautical Chart Data. MTS 91, New Orleans, LA, November 11-13, 1991.

ABSTRACTS:

Arnone, R.A., Optical Variability Off the East Coast Using CZCS Data. AGU, May 28-June 1, 1991

Arnone, R., G. Terrie, R. Oriol, Response of Surface Chlorophyll to Solar Irradiance in the Western Meditteranean. IUGG, Vienna and Russia, August 21, 1991.

Arnone, R.A., P.E. LaViolette, A Methodology to Determine Ocean Biological Climatology Using Regional Data Base Models. AGU, May 6, 1991.

Avera, W.E., Correlated Vector Magnetic Measurements for a 180 KM Baseline in the Gulf of Mexico. AGU, Baltimore, MD, May 28-June 1, 1991.

Avera, W., E. Mozley, D. Fraley, J. Reynaud, Vector Magnetic Measurements in a Shallow Ocean Environment Correlated with a Land Base Station 180 Km Distant. AGU, San Francisco, CA, December 14-16 1991.

McLeod, M.G., Noise and External Source Fields in Magnetic Observatory Annual Means, AGU Spring Meeting, Baltimore, MD, May 1991.

Mozley, E.C., Airborne Electromagnetic Technology, Electromagnetics Symposium, Laurel, MD, May 29-30, 1991.

Terrie, G.E., R.A. Arnone, R. Oriol, Modelling Global Solar Surface Irradiance, AGU Spring Meeting, Baltimore, MD, May 1991.

PRESENTATIONS:

Arnone, R.A., P.E. LaViolette, Coupling of the Chlorophyll and Physical Processes Across the Iceland-Faeroe Front Using Aircraft Sensors, Fourth Airborne Geoscience Workshop, La Jolla, CA, January 29 - Febebruary 1, 1991,

Mozley, E., "Advanced Airborne Electromagnetic Technology Innovative Monitoring Technologies--91 Review of Aquatic and Subsurface Monitoring." U.S. EPA, Environmental Monitoring Systems Laboratory-Las Vegas, NV, February, 1991,

MDFF TRANSITIONS

Lohrenz, M. C., P. Wischow, M. Trenchard, L. Riedlinger, H. Rosche, S. Briggs, CAC #CD-1991-A-MAP3-10004 (Northern Pacific Ocean at a Scale of 1:500,000 Scale) NTN 117, March 1991.

Lohrenz, M. C., P. Wischow, M. Trenchard, L. Riedlinger, M. Mehaffey, J. JOhnson, S. Tyskiewicz, J. Kaufman, M. Gendron, S. Myrick, H. Rosche III. CAC #CD-1992-A-MAP5-10008 (Africa, Eurasia and Australia at Scale of 1:2,000,000). NTN 202, December 1991.

Myrick, S., et al., CAC #CD-1991-A-MAP2-10007 (W. U.S. at 1:250K Scale), NTN 192, October 1991.

Riedlinger, L., H. Rosche, S. Briggs, M. Lohrenz, P. Wischow, M. Trenchard, CAC #CD-1991-A-MAP3-10006, (Unknown area and scale) NTN 140, July 1991.

Riedlinger, L., H. Rosche III, et al., CAC #CD-1991-A-MAP3-10003 (W. Pacific Rim at 1:500,000 Scale), NTN 98, February 1991.

Rosche, H., et al., CAC CD-1991-B-MAP3-10001 (Update of CD-1990-A-MAP3-00001), NTN 107, March 1991.

Rosche, H., et al., CAC CD-1991-D-MAP3-10000 (Prototype CAC with NOARL compression, using 1/1 method of generating codebooks; scale of 1:500K; isolated areas around the globe), NTN #200, November 1991.

Trenchard, M., L. Riedlinger, H. Rosche, S. Briggs, M. Lohrenz, Wischow, CAC #CD-1991-A-MAP3-10002 (Update of CD-1990-A-MAP-0002) NTN 139, May 1991.

Wischow, P., M. Trenchard, L. Riedlinger, H. Rosche, S. Briggs, M. Lohrenz, CAC #CD-1991-A-MAP3-10005 Mediterranean at 1:5000,000 scale, NTN 119, April 1991.

(Arnone)

COUPLING SURFACE CHLOROPHYLL AND SOLAR IRRADIANCE IN THE NORTH ATLANTIC

R. Arnone
G. Terrie
Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center, MS 39529-5004

R. Oriol
Planning Systems Incorporated
Slidell, LA 70458

Abstract

The monthly variability of the ocean chlorophyll distribution wasters is correlated with monthly averaged surface solar irradiance in the North Atlantic for 1979. The ocean's chlorophyll cycle is believed closely associated with the global carbon budget. Chlorophyll which compresses the majority of oceans carbon fixation, is stimulated by light (irradiance) and nutrient availability. In this paper, the influence of irradiance (@ 490 nm) on chlorophyll is presented for different ocean regions.

Mean monthly chlorophyll was computed from the Coastal Zone Color Scanner at a resolution of 20 km during 1979 for the North Atlantic. Total mean monthly surface irradiance at sea surface were modeled from data bases of a) aerosol optical depth (acquired from monthly 1979 CZCS; La670) b) ozone optical depth (acquired from daily 1979 Total Ozone Mapping Spectrometer) and c) percentage of cloud cover. Different ocean regions were analyzed representing the Equatorial, Northern Atlantic, Sargasso, African Upwelling and US shelf waters. Solar irradiance has a controlling influence on chlorophyll only in certain regions. Spring and fall blooms develop in regions where the strong seasonal cycle of irradiance is observed.

This research illustrates the application of satellite ocean color for characterizing the ocean's biological dependence on solar irradiance and provides an initial understanding of the seasonal distribution of carbon at the sea surface.

Sponsor by the Space and Naval Warfare Systems Command.

Presented at MTS '91, New Orleans, LA, November 11-13, 1991.

RESPONSE OF SURFACE CHLOROPHYLL TO SOLAR IRRADIANCE IN THE WESTERN MEDITERRANEAN

R. Arnone
G. Terrie
Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center, MS 39529-5004

R. Oriol
Planning Systems Incorporated
Slidell, LA 70458

Abstract

The monthly development of the chlorophyll distribution of surface waters of the Western Mediterranean is compared with monthly averaged surface solar irradiance. The growth and decay of the chlorophyll concentrations in the surface layer are shown to be strongly connected to the total solar irradiance distribution.

The Coastal Zone Color Scanner (CZCS) data was used to compute the monthly mean chlorophyll distribution at a spatial resolution of 20 km during 1979. In addition to characterizing the circulation, the monthly distribution show the temporal biological variabilities within specific ocean regions (Ligurian Sea, Gulf of Lion, Balearic Sea, Central Algerian Basin, Algerian Current, and Alboran Sea). Atmospheric models estimate coincident mean monthly solar irradiance (1979) at the ocean surface at 20 km resolution. Irradiance models assimilated data bases of a) aerosol optical depth (acquired from monthly 1979 CZCS; La670) and b) ozone optical depth (acquired from daily 1979 Total Ozone Mapping Spectrometer).

The rapid development of a spring chlorophyll bloom (April and May) in the Western Mediterranean shows strong dependence with increased solar irradiance. Increasing irradiance during summer shows a steady decline of the chlorophyll as the growth conditions are photo-inhibited. In late summer (Oct), the Western Mediterranean shows minimal chlorophyll concentration suggesting degeneration resulting from nutrient limitation.

This research illustrates the application of ocean color for understanding the role which the surface irradiance has on upper ocean biological responses in the Western Mediterranean.

Sponsored by Space and Naval Warfare Systems Command.

Presented at the IUGG Meeting in Vienna, 21 August 1991.

(Arnone)

COUPLING OF THE CHLOROPHYLL AND PHYSICAL PROCESSES ACROSS THE ICELAND-FAEROE FRONT USING AIRCRAFT SENSORS

R. Arnone
Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center, MS 39529-5004

P. La Violette
Mississippi State University
Stennis Space Center, MS 39529

Abstract

The ocean surface color (water-leaving radiances) and thermal structure across the Iceland-Faeroe Front under both clear and cloudy conditions were measured from a NASA research aircraft on 25 May 1989. The measurements were made along four north-south lines that were 125 km in length and spaced 35 km apart. The color measurements were made with a 14 channel, non-polarized Multispectral Airborne Radiometer System (MARS) while the thermal data were collected by a thermal radiometer and aircraft bathythermographs. The satellite imagery (NOAA AVHRR) sequence show the development of meanders through the frontal region. These aircraft ocean color and thermal data characterize the biological distribution and are closely coupled to the physical processes occurring in the frontal systems. The ratio of several channels of the ocean color data are used to determine the surface chlorophyll. The retrieved data correlate well with (a) laser-induced chlorophyll fluorescence obtained at the same time and (b) historical chlorophyll data.

The observed chlorophyll patchiness appearing across the Iceland-Faeroe Front is believed to be directly and indirectly related to primary and secondary circulation processes in ocean frontal systems. High chlorophyll concentrations were observed on the north side of the front and are inferred to be the result from the advection of Icelandic Coastal Water into the region. The sharp chlorophyll declined at and south of the thermal frontal boundary is clearly related to the subsurface thermal strsucture.

Sponsor: Chief of Naval Operations (OP-096).

Presented at the Fourth Airborne Geoscience Workshop, La Jolla, CA, January 29 - February 1, 1991.

(Arnone)

OPTICAL VARIABILITY OFF THE EAST COAST USING CZCS DATA

R. Arnone
Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center, MS 39529-5004

W. Elenbaas
Naval Oceanographic Office
Stennis Space Center, MS 39527

Abstract

The scales of optical variability for selected East coast water masses were examined using historical Coastal Zone Color Scanner monthly composites. Monthly climatology was determined from 1978 to 1986 of the diffuse attenuation coefficient; k(490) for the 1. Shelf 2) Slope 3) Gulf Stream and 4) Sargasso waters. The mean and standard deviation of k(490) for these waters were derived from water leaving radiance from standard NASA Goddard CZCS products (Feldman et al. 1987) and k(490) algorithms (Mueller et al, 1990). Results show distinct differences in the optical properties of these water masses with Shelf having the highest, followed by the Slope, Gulf Stream and Sargasso having the lowest k(490) values. Minimum values were observed in summer compared with elevated values in spring. Shelf waters show the strongest monthly k(490) change from 0.097 m-1 in Spring to 0.06 in Summer. Sargasso waters remain low in all months at 0.032 m-1. Inter-annual variability of these water masses is shown to be well correlated with the mean, i.e.; high mean values of the shelf waters have covarying high standard deviation. This suggests methods of discrimination of the water masses based on the statistics from optical climatology.

Sponsor: Chief of Naval Operations, Program Element 63704N.

Abstract for AGU, May 28-June 1, 1991, Baltimore, MD.

A METHODOLOGY TO DETERMINE OCEAN BIOLOGICAL CLIMATOLOGY USING REGIONAL DATA BASE MODELS

B. Arnone
Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center, MS 39529-5004

P. La Violette
Mississippi State University
Stennis Space Center, MS 39529

Abstract

Because satellite-derived chlorophyll (e.g. by the Coastal Zone Color Scanner) is limited to surface distribution, major biological activities in the ocean lie beyond direct satellite observation. However, by coupling the satellite-derived surface distribution with other distributions such as mixed layer depth, vertical irradiance, etc. the vertical biological distribution may be realistically inferred. From this, it is assumed that regional data bases of these distributions can form the foundation to model the ocean's biological distribution.

At this time, the limitations of available data from all sources dictate that monthly composite or averaged regional data bases be used for such modelling (indeed, the applications of these monthly composites are more easily adapted to our present modelling capability which have not evolved sufficiently to address "small" scale processes on a regional basin scale). In the case of satellite data, a monthly ocean climatology is preferred over the normal "snapshot" views of mesoscale features provided by single satellite passes. These composites present a view of an entire ocean basin, retaining the long-lasting features that because of their persistent are more meaningful in relation to the ocean's bulk energy and biological distribution.

The obvious interaction of properties within the various regional data bases provide an easy methodology to understand the spatial inter-comparisons of these ocean properties. For example, the relationships of the surface irradiance distribution at the sea surface can be shown to spatial accelerate growth of the surface chlorophyll. What makes modelling regional data bases attractive is that it addresses large scale ocean processes, illustrating the complex distributions and interactions taking place in the regional oceans. As our understanding of these processes develop, additional elements can be easily added to the data base (i.e. wind stress, nutrients).

With the increased ocean color satellite support for oceanographic surveillance, improved and real time data base will supplement biological and physical data bases, thereby improving our understanding and modelling capability.

Sponsor by the Space and Naval Warfare Systems Command.

Presented at the 23rd International Liege Colloquium on Ocean Hydrodynamics at Liege, Belgium, May 6-10, 1991.

(Avera)

ACCURACY IMPROVEMENTS IN THE APPLICATION OF THE RING-CORE FLUXGATE MAGNETOMETER

W. Avera
J. Ross
T. Nicolaides
G. McCardle
M. Thiele

Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center, MS 39529-5004

Abstract

A ring-core fluxgate magnetometer is being considered for installation on the Naval Oceanographic Office Project Magnet aircraft. The Naval Oceanographic and Atmospheric Research Laboratory was tasked to determine the feasibility of the new magnetometer's airborne application and to explore methods to assure accuracy in its use. To carry out these tasks, an initial test flight was conducted. This test pointed out the feasibility of this magnetometer for airborne applications but identified accuracy deficiencies. The results of laboratory work concerning the cause of the inaccuracy and a second flight that verifies improvements are reported here. These results are closer to those desired. This report describes the process used and the instrumentation configuration that yielded the results.

Sponsor: Naval Oceanographic Office under program element OPN.

Published as NOARL Report 12, January 1991.

CORRELATED VECTOR MAGNETIC MEASUREMENTS FOR A 189 KM BASELINE IN THE GULF OF MEXICO

W. Avera
C. Young
E. Mozley
D. Fraley
J. Reynaud
Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center, MS 39529-5004

Abstract

Magnetic measurements for the frequency range 0.0007 - 0.5 Hz in the Gulf of Mexico indicate a good correlation to land based measurements 180 Km away. Vector magnetic data were acquired on the ocean bottom in 40 m of water. A simultaneous data recording system 180 Km away at the NOARL Magnetic Observatory recorded the same geomagnetic pulsations. Data indicate that geomagnetic noise in this frequency range can exhibit a high degree of coherence over large spatial distances. Onshore magnetotelluric (MT) measurements reveal the conductivities to exhibit a horizontally layered structure in the vicinity of these long baseline magnetic measurements.

Data from these recent onshore MT sites are consistent with an offshore MT measurement by Mobile Oil. Lateral increasing conductivity from onshore toward the coastline is observed in an interpreted layer extending from near the surface to on the order of 500 m depth.

Offshore long baseline data are recorded with an autonomous ocean magnetometer system (OMS). The primary magnetic sensor at both onshore and offshore recording stations is a ring core fluxgate magnetometer. Offshore data are compensated for motion induced noise and orientation with tiltmeter and angular accelerometer measurements.

Sponsor: Office of Naval Research.

Presented as a poster at AGU, May 28-June 1, 1991, Baltimore, MD.

(Avera)

A NEW OCEAN BOTTOM MAGNETOMETER SYSTEM FOR CONTINENTAL SHELF MEASUREMENTS

W. Avera
D. Fraley
J. Reynaud
LT D. Byman
Naval Oceanographic and Atmospheric
Research Laboratory
Stennis Space Center, MS 39529-5004

Richard Burgett
Planning Systems, Inc.
Slidell, LA 70458

ABSTRACT

The Naval Oceanographic and Atmospheric Research Laboratory (NOARL) initiated the development of an Ocean Magnetometer System (OMS) to conduct research measurements of the ocean magnetic environment on the continental shelf and in shallow marginal seas. Little is known of the magnetic environment on the shallow continental shelf areas. Most vector magnetic measurements conducted in the ocean are from the deep ocean basins. Motion of the magnetic sensor is a major limiting factor in shallow water vector magnetic measurements.

The new technology incorporates motion sensors with a vector magnetometer to improve the signal/noise of the vector magnetic measurements. In an experiment in the Gulf of Mexico, the signal/noise of the vector magnetic measurements are improved by as much as 20 dB utilizing the motion sensor data.

Some of the advances in design and data processing for this system can have a significant impact on future underwater magnetometer recording systems for continental shelf research. This system could also serve as a temporary geomagnetic monitoring station for shallow marginal sea deployment locations where land stations are not available.

Sponsor: Office of Naval Research.

Presented at MTS '91, New Orleans, LA, 11-13 November 1991.

VECTOR MAGNETIC MEASUREMENTS IN A SHALLOW OCEAN ENVIRONMENT CORRELATED WITH A LAND BASE STATION 180 KM DISTANT

W. Avera
E. Mozley
D. Fraley
J. Reynaud
Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center, MS 39529-5004

Abstract

Geomagnetic time series are compared to show the correlation of the vector components between a land based station and an ocean based station approximately 180 Km apart. The residual between the two stations was computed using a frequency dependent transfer function prediction technique. This procedure demonstrated a 12.5 dB improvement in the signal/noise for reducing geomagnetic temporal variations. The data recorded offshore were obtained using a new Ocean Magnetometer System (OMS) developed for vector magnetic measurements in continental shelf and marginal sea environments. Two techniques are investiga d for motion noise reduction using data from the OMS. An adaptive interference cancelir g technique was selected for the motion noise reduction procedure.

Sponsor: Office of Naval Research.

Abstract submitted AGU, San Francisco, CA, December 14-16, 1991.

SURVEILLANCE WITH DEPLOYABLE DISTRIBUTION SYSTEMS AND THE IMPACT OF ELECTROMAGNETIC NOISE SOURCES

W. Avera
E. Mozley
Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center, MS 39529-5004

Abstract

The salient environmental characteristics for coastal areas that impact the operational deployment of electric and magnetic field sensors are identified. The relative importance of significant noise sources is described, techniques for modelling their effects are reviewed, and their impact on deployable distributed electromagnetic surveillance systems are summarized. Experimental plans for validating some of these models are proposed. Finally, plans and recommendations to utilize these models in developing an array performance evaluation capability are presented.

Sponsored by the Naval Ocean Systems Center, Program Element 0602314N.

Published as NOARL Technical Note 181.

DESIGN OF THE GEOPHYSICAL AIRBORNE SURVEY SYSTEM: A DISTRIBUTED MICROPROCESSOR APPLICATION

B. Bourgeois
M. Harris
P. Wischow
Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center, MS 39529-5004

Abstract

This paper discusses the design of the Geophysical Airborne Survey System (GASS). GASS was developed by the Naval Oceanographic and Atmospheric Research Laboratory (NOARL) and is a real-time, distributed microprocessor sensor system. The Naval Oceanographic Office (NAVOCEANO) intends to use this system on the Project Magnet P-3 Orion aircraft to collect worldwide magnetic and hydrographic data.

The paper begins with a brief discussion of the mission and history of GASS. Then, a review is given of the advances made during the last decade in the area of real-time distributed microprocessor systems. The final GASS design has eight Motorola MC68020 based nodes interconnected by a MIL STD-1553B based network. Six of these nodes are used for sensor interfacing. The other two nodes are used for operator interfacing, data recording, and data processing.

Sponsored by the U.S. Naval Oceanographic Office under program element #980101.

Published in *MICROCOMPUTER APPLICATIONS*, Volume 10, No. 1, April 1991.

(Bourgeois)

HIGH ACCURACY MAGNETIC MEASUREMENTS WITH THE ASQ-81 SCALAR MAGNETOMETER

B. Bourgeois
J. Ross
W. Avera
Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center, MS 39529-5004

Abstract

The Texas Instruments' ASQ-81 scalar magnetometer provides high resolution total field magnetic measurements. The ASQ-81 uses an optically pumped metastable helium gas detector that has a range of 23000 to 75000 gammas and a .016 gamma peak-to-peak noise level. Total magnetic field measurements can be made using the resonance oscillator output of the magnetometer. The resonance oscillator output is a frequency modulated signal whose center frequency is the Larmor frequency. For sampling rates slower than .5 Hertz the Larmor frequency can be measured directly from the resonance oscillator using a frequency counter. At higher sampling rates the modulation of the resonance oscillator output can create measurement errors that exceed the instrument's noise level. This paper quantifies this measurement error and describes the circuitry and techniques required to reduce the measurement error to less than the instrument noise level.

Sponsor: Naval Oceanographic Office, program element 980101.

Published in IEEE INSTR. & MEASUREMENT, Vol 40, No. 4, August 1991.

(Bourgeois)

NEURAL NETWORK SEAFLOOR CHARACTERIZATION FROM SIDESCAN SONAR IMAGERY

B. Bourgeois
A. Martinez
C. Walker
Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center, MS 39529-5004

Abstract

This paper investigates the use of neural networks for the direct estimation of image texture. Unlike previous approaches where networks are used to make decisions on feature vectors derived from traditional techniques, or where a network is trained to perform the function of a traditional technique, the proposed approach will use a network to directly model texture. The envisioned approaches to this method are described and the results of the preliminary 1-dimensional tests are presented.

Sponsor: This work was supported by the Office of Naval Technology, Program Element #62435N.

Presented at MTS '91, New Orleans, LA, November 11-13, 1991.

NONLINEAR PHENOMENA IN ADAPTIVE LMS FILTER SIGNALS

B. Bourgeois
A. Martinez
Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center, MS 39529-5004

Abstract

This paper demonstrates that the adaptive LMS filter does not necessarily converge to the Wiener Solution. Iteration analysis is introduced and applied to the structure of the estimate and error signals for the filter is investigated for an N tap filter. Simulation results are provided which collaborate the theoretical findings.

Sponsor: Office of Naval Technology, Program Element #62435N.

Published in IEEE Proceedings of the IEEE Southeastcon '91, Volume 2.

(Bourgeois)

SIDESCAN SONAR IMAGE INTERPRETATION WITH NEURAL NETWORKS

B. Bourgeois
C. Walker
Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center, MS 39529-5004

Abstract

This paper investigates the use of neural networks for the direct estimation of image texture. Unlike previous approaches where networks are used to make decisions on feature vectors derived from traditional techniques, or where a network is trained to perform the function of a traditional technique, the proposed approach will use a network to directly model texture. The envisioned approaches to this method are described and the results of the preliminary 1-dimensional tests are presented.

Sponsor by the Office of Naval Technology, Program Element #62435N.

Published in the Proceedings of the IEEE Oceans '91, Honolulu, Hawaii, October 1-3, 1991.

TEXTURE ESTIMATION WITH NEURAL NETWORKS

B. Bourgeois
C. Walker
Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center, MS 39529-5004

Abstract

This paper investigates the use of neural networks for the direct estimation of image texture. Unlike previous approaches where networks are used to make decisions on feature vectors derived from traditional techniques, or where a network is trained to perform the function of a traditional technique, the proposed approach will use a network to directly model texture. The envisioned approaches to this method are described and the results of the preliminary 1-dimensional tests are presented.

Sponsored by the Office of Naval Technology, Program Element #62435N.

Published in the Proceedings of the IEEE Conference on Neural Networks for Ocean Engineering, August 15-17, 1991, Washington, DC.

ISSUES OF DATA CONTENT AND STRUCTURE REQUIREMENTS FOR SPATIALLY ORIENTED OCEANOGRAPHIC/HYDROGRAPHIC FEATURE DATA

J. Breckenridge
Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center, MS 39529-5004

Abstract

The complexity, diversity, and temporal variance of shallow and deep water oceanographic/hydrographic features requires a broad implementation of theory associated with spatial feature attribution and topological data storage techniques. Effective and concise representation of these features in a digital format depends directly upon the capability of the data structure to store, retrieve, and convey topological correlations inherent within the feature entities and their attributes. The successful development of a master seafloor digital database (MSDDB) of oceanographic/hydrographic information requires intensive definition of the individual geometric data entities, i.e., polygonal faces, line edges, and nodes; and their associated attributes, i.e., depth, wave height, light attenuation. The effectiveness of the data structure at maintaining a relationship between geometric features and spatial attributes significantly impacts the ability of the GIS to retrieve and demonstrate realworld oceanographic/hydrographic phenomena.

This examination of data content and structure definitions for storing oceanographic/hydrographic feature information focuses upon aspects of existing spatial data structures and attribution schema for portraying the dynamic nature of the seafloor environment. Clarification of the basic geometric and spatial feature entities associated with oceanographic/hydrographic features and their abstract digital representations is needed to further define a set of general guidelines to support the successful compilation, encoding, and relational analysis of hydrographic information.

Sponsored by the Defense Mapping Agency Systems Center, Code SGE.

Presented at GIS/LIS, Atlanta, GA, 1 November 1991.

(Carter)

SP 020:351:91

Scientific and Technical Information

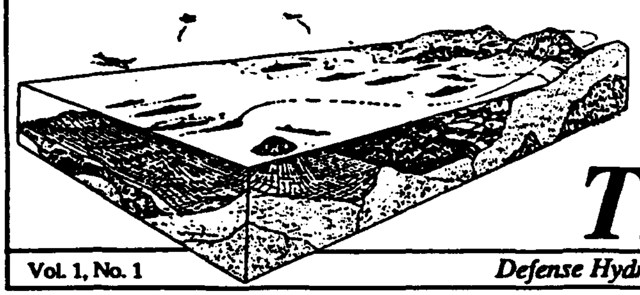
for the Naval Digital MC&G Interest Group

Winter 1991

Destruction Notice - For unclassified documents, handle by the same standard as applied to "For Official Use Only (FOUO)" material, and destroy by any method that will prevent disclosure of contents or reconstruction of the document. For classified documents, follow the handling and destruction procedures shown in OPNAVINST 5510.1 series or DOD 5200.22-M.

Distribution authorized to U.S. Government agencies and their contractors (Administrative or Operational Use; 5/91). Other requests for this document will be referred to Commanding Officer, Naval Oceanographic and Atmospheric Research Laboratory, Stennis Space Center, Mississippi 39529-5004.

SP023:351:91



The DHI Perspective

Vol. 1, No. 1 — *Defense Hydrographic Initiative* — Summer 1991

WHAT IS DHI?

The Defense Hydrographic Initiative (DHI) charter establishes and endorses the concept of the DHI to provide formal coordination among the Defense Mapping Agency (DMA), the Oceanographer of the Navy (CNO OP-096) and the National Oceanic and Atmospheric Administration/National Ocean Service (NOAA/NOS) regarding the collection, processing, archiving, analysis, integration, production, and distribution of hydrographic and bathymetric sounding data, and transition to support digitial products to the user community.

[Ed. note: DMA, CNO OP-096, and NOAA/NOS all signed the Charter which was ratified by final signature on 20 June 1991.]

Background

The DoD and civil maritime communities require hydrographic and bathymetric data of ever increasing accuracy and coverage. The availability of precise satellite and navigation systems, as well as the integration of these systems with DoD C^3I and fire control systems, highlight the expanding demand for these data. The diversity of supply sources (e.g., academia, industry, DoD laboratories, Navy, DMA, NOAA/NOS, and foreign) requires coordination and oversight. Additionally, emerging technologies for application of MC&G data require product specification and implementation.

Scope

The DHI is a cooperative interagency effort that addresses hydrographic requirements for products and services to ensure concept continuity for research, development, production, and distribution of hydrographic and bathymetric products. To accomplish this initiative, the DHI is focused in the following three primary thrust areas:

a. Standardization of hydrographic/bathymetric data collection, processing/evaluation, archiving, and analysis/integration.

b. Product and service identification and definition, and implementation of the necessary support process.

c. Coordination of research and development (R&D) initiatives among academia, private industry, allied hydrographic offices, and international organizations as appropriate.

Definitions

For purposes of this charter, the following definitions apply:

Hydrographic Data. Measurement, description, and mapping of the earth's waters with special reference to their use for safe navigation.

Bathymetric Data. Ocean depth and seafloor 3-D description.

Responsibilities

Each member agency agrees to work together to achieve consensus of operational and technical development issues within the hydrographic community. Furthermore, upon establishing a consensus, member agencies will participate in these mutually beneficial cooperative efforts to the extent of their respective resource availability. Authority of the DHI is limited to that which has been willingly granted by the member agencies.

Organization

The following four organizational levels are established for the interagency coordination of DHI:

Policy Steering Group (PSG)
The PSG, chaired by DMA, consists of senior managers from DMA, CNO (OP-096) and NOAA/NOS who direct specific goals and objectives in support of the DHI.

Technical Steering Group (TSG)
The TSG, chaired by DMA, consists of senior technical personnel who develop, maintain, and execute a Long Range Plan that articulates the policies of the PSG regarding the implementation of new and emerging MC&G technology. Additionally, the TSG maintains and prioritizes a Technical Development Data Base of specific R&D initiatives, and establishes standing working groups to focus on major technical development areas. TSG members act as points of contact for actions assigned to their respective organizations.

Working Group
A working group, chaired by an agency member, consists of technical personnel who perform those actions required to execute the Long Range Plan, and propose development strategies in their respective areas of responsibility for review and staffing by the TSG and final approval and implementation by the PSG. A working group organizes subgroups as needed, or groups or committees, for support in the development of specific R&D initiatives. Approved initiatives are forwarded to the TSG for review and entry into the Technical Development Data Base.

Subgroup
A subgroup, chaired by an agency member, consists of technical personnel who are focused in resolving specific issues. A subgroup documents and recommends approaches, and develops task descriptions that can be programmed for work by agency in-house resources or considered for funding as a contractual effort. Specific task descriptions developed by a subgroup form the basis for implementing the DHI strategy. Subgroup initiatives must be coordinated up the DHI organizational chain of command prior to implementation.

Contents

The DHI Perspective is an unclassified scientific and technical publication funded by the Defense Mapping Agency Systems Center and published quarterly by the Naval Oceanographic and Atmospheric Research Laboratory Mapping, Charting and Geodesy Division. The primary objective of the DHI is to provide formal coordination among the Defense Mapping Agency, the Oceanographer of the Navy (CNO OP-096), and the National Oceanic and Atmospheric Administration/National Ocean Service regarding the collection, processing, archiving, analysis, integration, production, and distribution of hydrographic and bathymetric sounding data, and transition to support of digital products to the user community.

For additional information concerning DHI, contact Kevin Brown, DMASC, (703) 285-9250 or AUTOVON 356-9250. For information regarding The DHI Perspective, contact Susan Carter, NOARL, (601) 688-4652 or AUTOVON 485-4652. Material may be reprinted without permission; however, credit to the source would be appreciated. *Any use of trade names and trademarks in this publication is for identification purposes only and does not constitute endorsement by the Federal Government.*

EIGENANALYSIS OF BOTTOM REFLECTANCE SPECTRA

L. Estep
Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center, MS 39529-5004

Abstract

An eigenanalysis is performed on *in situ* bottom reflectance data which have been computed by extrapolation from water reflectance data as a function of depth for different sites. It is established that 99% of the variation seen in the spectra are derived from the 516nm and 596nm spectral channels. Data on the sediments and a statistical test in the form of a cluster analysis are presented to check the robustness of the results for application in other areas besides those where the sediments were originally collected.

Sponsored by SPAWARS under the Air Defense Initiative and Office of Naval Research.

Published in The Hydrographic Journal, No. 62, October 1991.

(Estep)

IMPACT ON THE MEDIUM MTF BY MODEL ESTIMATION OF B

L. Estep
B. Arnone
Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center, MS 39529-5004

Abstract

The objective of this paper is to utilize Well's results to compute the medium decay function using both the value of b computed with the above mentioned relationships and experimentally determined values of b. The resulting decay function expressions will be compared to provide a measure of the errors introduced by using the various estimation methods. Finally, comments will be made on which model appears to provide the most accurate estimation of b.

Funded under the Optical Properties and Laser Backscatter 6.1 Project funded by Office of Naval Research.

Presented at SPIE, San Diego, CA, July 21-26, 1991.

(Estep)

BEAM AND DIFFUSE OPTICAL COEFFICIENTS FROM LASER BACKSCATTER: THEORY AND EXPERIMENT

L. Estep
J. Kaufman
R. Arnone
Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center, MS 39529-5004

Abstract

Experimental work on the correlation of optical coefficients to laser backscatter have been performed to provide a foundation for the development of laser based optical oceanographer instrumentation. Results of these correlations with the beam attenuation, absorption, scattering, and diffuse attenuation coefficients will be presented. Also, a comparison of the experimental data with salient models is given.

Sponsored by SPAWARS under the Air Defense Initiative and Office of Naval Research.

Presented at IGARSS'91, Espoo, Finland, June, 1991.

ESTIMATORS OF BOTTOM REFLECTANCE SPECTRA

L. Estep
Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center, MS 39529-5004

J. Holloway
Naval Coastal Systems Center
Panama City, FL 32407

Abstract

Estimators of in situ bottom spectral reflectance are calculated from multi-station optical field data gathered with standard instrumentation from different sites. These spectra are then compared to reflectance spectra measured in the laboratory of the bottom sediments collected in the field for the stations at these different sites. The relative fit of the estimated spectral curves to those measured in the laboratory was measured. The most accurate absolute estimation was provided by the single scattering irradiance model.

Sponsored by the Oceanographer of the Navy, OP-096.

Published in the International Journal of Remote Sensing, April, 1991.

RESIDUAL TOTAL FIELD MAGNETIC ANOMALY MAP OF NOARL'S MAGNETIC OBSERVATORY

C. Estes
W. Avera
Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center, MS 39529-5004

Abstract

The purpose of this survey is to create an accurate residual magnetic contour map of the Magnetic Observatory area at Stennis Space Center. Measurements were completed covering the observatory grounds. A map of the magnetic residuals is presented.

This work was sponsored by the Office of Naval Research, Program Element 61153N.

Published as NOARL Technical Note 125, April 1991.

(Fay)

AN AUTOMATIC GENERAL PURPOSE LINEAR FEATURE EXTRACTOR FOR DIGITAL MULTISPECTRAL IMAGERY

T. Fay
V. Miller
Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center, MS 39529-5004

Abstract

A parallel general purpose feature detection method is described based on signal strength (bright thresholding) and connectedness. The method is based upon the article *Automatic road identification and labeling in Landsat 4 TM images* by J. Ton, A. K. Jain, W. R. Enslin, and W. D. Hudson [2]. Conceptually, it is useful to think in terms of road identification in an image, with the understanding that the algorithm is helpful in identifying other cultural features such as airport runways, docks, jetties, and railway lines. Although many road detection methods are available, few work on satellite imagery in which most roads are only one or two pixels wide; the same can be said about other cultural features in such imagery. The technique consists of several phases: image sharpening which determines a most likely road direction a magnitude for each pixel; seed selection determining those pixels most likely to be in a feature; a line following technique. A multispectral approach and a slightly improved line following technique are employed to obtain an improvement over the algorithm described in [2].

Sponsor: This work was supported by the Office of Naval Technology, Program Element #0602435N.

Presented at MTS '91, New Orleans, LA, November 11-13, 1991.

UNDERWATER MAGNETIC SIGNATURE MEASURING SYSTEM (MAGMES)

D. Fraley
W. Avera
T. Kooney
J. Reynaud
Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center, MS 39529-5004

Abstract

This technical note documents the design and constructing of a portable underwater magnetic field signature measuring system in support of the Navy underwater mine countermeasure program. The system will be used to measure the magnetic signature of divers, small craft, and motors associated with underwater mine disposal.

The system hardware and electrical drawings, software listings, general maintenance procedures, and operating guide are provided in the form of the System's Manual.

Sponsored by the Naval Explosive Ordnance Disposal Technical Center under program element #0604654N.

Published as NOARL Technical Note 169, September 1991.

(Hsu)

COUPLING REGIONAL AND GLOBAL TIDE MODELS

J. K. Lewis
G. A. Vayda
Science Applications Int'l. Corp.
Long Beach, MS 39560

Y. L. Hsu
Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center, MS 39529-5004

Abstract

A two-dimensional numerical model was used to study appropriate conditions at the open boundaries for a regional model forced by parameters from Schwiderski's (1981, 1983) global tidal model. The open boundary condition of Reid and Bodine (1968) was applied to regional models of the north-central Gulf of Mexico and of the western Florida shelf. A number of tests were conducted to determine how well forcing using the tidal constants from the 1°x1° Schwiderski global model could reproduce the M_2 and O_1 tides as determined from observations and the 15'x15' Gulf of Mexico model of Reid and Whitaker (1981). The Reid and Bodine formulation was quite effective in driving the regional models while still allowing wave energy to propagate through the open boundaries and out of the model. Tests with one open boundary of the north-central Gulf regional model having just a radiation or a zero-gradient ccondition (but no tidal forcing for either) failed to reproduce the known tides. Apparently the pure radiation or zero-gradient condition along one open boundary can result in interior solutions to the tidal forcing which can be quite different from the actual tides. The results indicate that tidal forcing is required at all open boundaries to reproduce observed and model-predicted tidal variations.

The western Florida shelf is known to resonate with the M_2 tide. Under such circumstances, the bottom friction becomes quite important in obtaining correct predictions of the observed tidal amplitudes. Several bottom friction schemes with varying drag coefficients were tested for both the central Gulf and Florida models. The results are discussed in light of the fact that we seek one scheme which would be applicable for both resonant and non-resonant situations.

Sponsor by Chief of Naval Technology under Program Element 063704N.

Presented at MTS'91, New Orleans, LA, November 11-13, 1991.

(Hsu)

OPEN BOUNDARY CONDITIONS FOR A COASTAL TIDE MODEL

Y. L. Hsu
Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center, MS 39529-5004

J. K. Lewis
G. A. Vayda
Science Applications Int'l. Corp.
Long Beach, MS 39560

Abstract

Both offshore and cross-shelf open boundary conditions for a two-dimensional coastal tide model were evaluated. The tidal forcing was provided by a global tide model of Schwiderski. Various radiation boundary conditions were used to determine the appropriate coupling schemes between regional and global tide models. Radiation condition was applied at boundaries to allow disturbances generated within the modeling region to propagate out as free progressive waves. Test runs were conducted for both semidiurnal M2 and diurnal O1 tides over the Northern Gulf of Mexico between 27° N and 30° N. Comparison of cotidal and corange charts were made between computed results and Reid and Whitaker's gulf tide model. Computed tidal heights were compared with predicted heights from tidal stations. Among various coupling schemes, the Reid and Bodine formulation of radiation/tidal condition when applied to all open boundaries produced the best agreement. Further refinement on the radiation condition constrained by the global tide model is being evaluated.

Sponsored by the Office of Naval Technology, Program Element #62435N.

Published in EOS Trans., AGU, April 91, Vol. 72, No. 17, Pg. 168.

MULTISPECTRAL SOFTWARE DEVELOPMENT FOR THE AIRBORNE BATHYMETRIC SURVEY SYSTEM

M. Kalcic
S. Lingsch
Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center, MS 39529-5004

Abstract

The Mapping, Charting, and Geodesy (MC&G) Division of the Naval Oceanographic and Atmospheric Research Laboratory's Ocean Science Directorate is the primary activity within the U.S. Navy for conducting research and development in direct support of naval MC&G requirements. The Mapping Sciences Branch of the MC&G Division was tasked to develop the algorithms and software necessary to process data and to produce bathymetry from the multispectral scanner of the Airborne Bathymetric Survey system when it becomes fully functional. The software developed for this system is called the Multispectral Image Depth Analysis System, or MIDAS. The software processes multispectral data in conjunction with laser-or boat-derived soundings to produce high-resolution bathymetric grids. The system is designed to estimate depths in clear, shallow coastal waters down to 20 m. The depth accuracies, derived from the system using boat soundings for control, ranged from 0.3 m to 1.4 m in waters extending to 3 m and 10 m, respectively. The horizontal positioning accuracy of the system was in the 24-m range, as determined from a ground survey.

Sponsor: This project was initially funded by the Defense Mapping Agency under Program Element 63701B, with final funding from the Chief of Naval Operations (CNO OP-096) under program element 63704N.

Published as NOARL Report 17, May 1991.

MILITARY SPECIFICATION
THE NAVY STANDARD COMPRESSED AERONAUTICAL CHART (CAC) DATABASE

M. Lohrenz
Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center, MS 39529-5004

Abstract

These specifications are designed to provide guidelines for the preparation and use of Compressed Aeronautical Chart (CAC) data to support various weapons and mission support systems. CAC data are designed to provide support data and computer readable digital images of hard-copy graphic products for naval mission planning systems and digital moving map systems. CAC data are directly derived from Equal Arc Second Raster Chart (ARC) Digitized Raster Graphics (ADRG) data. ADRG is first transformed from the ARC projection system into the Tesselated Spheroid (TS) projection system, and then the data is compressed. The total compression ratio achieved in processing ADRG data into CAC is 48:1.

Sponsored by the Naval Air Systems Command, AV-8B, F/A-18, V-22, and A-12 programs, under program elements 940101 (0604214N, 0604252N, and 0604233N) and 980101 (APN).

Published as Special Project 024:351:91, August 1991.

COMPRESSION OF SCANNED AERONAUTICAL CHART DATA IN SUPPORT OF NAVAL AIRCRAFT DIGITAL MOVING MAP SYSTEMS

M. Lohrenz
H. Rosche, III
M. Trenchard
Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center, MS 39529-5004

Abstract

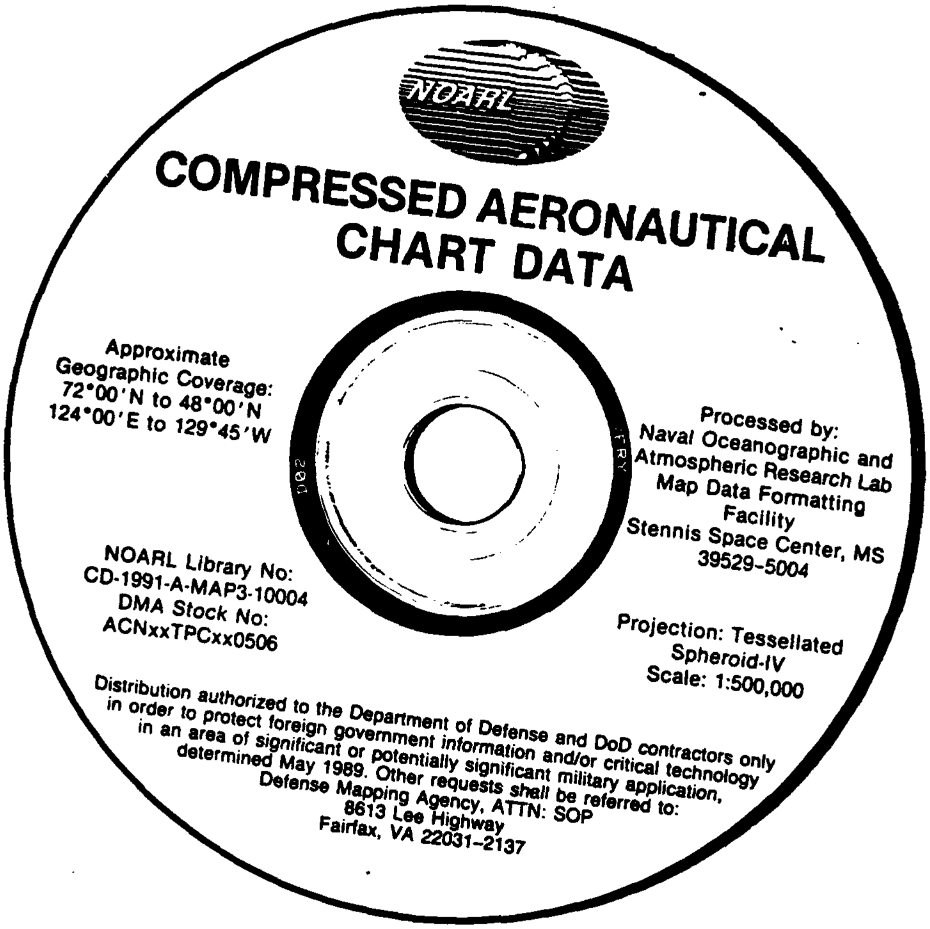
The Map Data Formatting Facility (MDFF), located at the Naval Oceanographic and Atmospheric Research Laboratory (NOARL), is developing a global database of compressed, scanned, aeronautical chart images, called the Compressed Aeronautical Chart (CAC)[1]. The CAC is stored as a library of Compact Disk-Read Only Memory (CD-ROM) optical discs which are being distributed by the Defense Mapping Agency (DMA). Six different chart scales, ranging from 1:50,000 to 1:2,000,000, will be supported in the CAC. The primary users of this compressed digital chart library are aircraft mission planning systems and digital moving map systems, including those for the AV-8B Harrier, F/A-18 Hornet, V-22 Osprey, and A-12 Avenger II. The MDFF processes raw scanned chart data (DMA's Arc Digitized Raster Graphics (ADRG)) by first transforming the data from DMA's Equal Arc Second Raster Chart (ARC) map projection system into another projection system, known as the Tessellated Spheroid (TS), and then applying two compression algorithms to the data. The final compression ratio that is achieved is 48:1.

The original software that was used by the MDFF to compress ADRG into CAC was developed by a government contractor and is proprietary, although the contractor's documentation indicates that the compression techniques are based on a form of vector quantization. The MDFF project does not have access to the source code for the compression algorithms and, therefore, the algorithms cannot be used on any computer system except that for which they were written (VAX/VMS). In August of 1989, the Oceanographer of the Navy (CNO OP-096) recommended that the CAC be made the Navy Standard for compressed aeronautical chart data. For this to be realized, it was important that NOARL be able to provide other government facilities with the compression algorithms that are used to create CAC. In addition, a new supercomputer was made available to NOARL this fall, and scientists at the MDFF were interested in testing the compression software on this new platform in the hopes of increasing processing speeds. Without the compression source code, neither of these goals was attainable.

Therefore, in the spring of 1990, MDFF computer scientists set out to develop a new suite of data compression algorithms that would produce images of similar or superior quality to those that were produced with the original software. Existing system requirements stipulated that the output map image files, color palette files, and decompression tables have formats that were identical to the original output files, and that output image quality be comparable or better. This paper describes the compression techniques that were developed and compares the resulting CAC image data with the data that is being produced by the original, proprietary software. An earlier paper[2], which was presented at IEEE's PLANS'9O Symposium, provides more background information about the MDFF project and the CAC library. The new, government-developed techniques that we described in this paper for scanned charts may be applicable to other types of image data as well, including remotely-sensed multispectral data, gridded bathymetric data, and swaths of acoustic imagery.

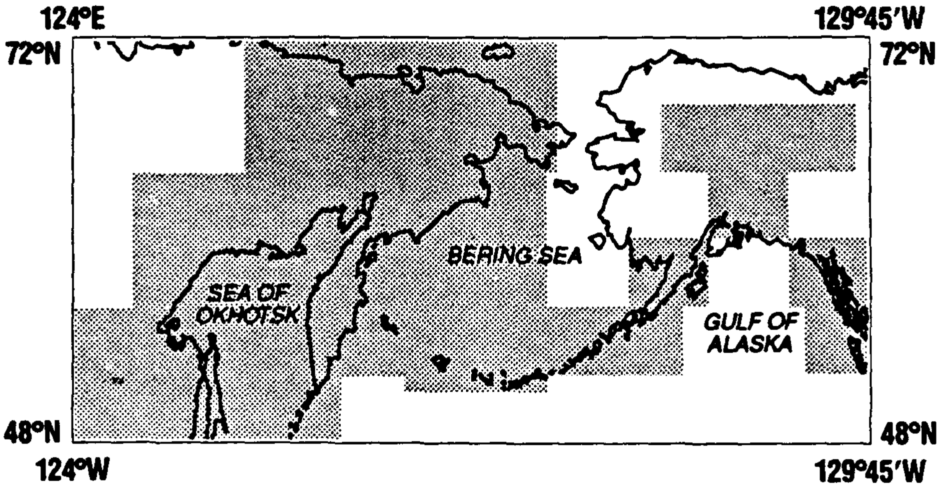
Sponsored by the Naval Air Systems Command (NAVAIR) and has been funded for the past four years by the AV-8B, F/A-18, A-12, and V-22 programs under Aircraft Procurement, Navy H1CC, program elements 9410101 (64262N) and 980101 (APN).

Presented at IEEE, Snowbird, Utah, April 8-11, 1991.



DMA Stock No: ACNxxTPCxx0506

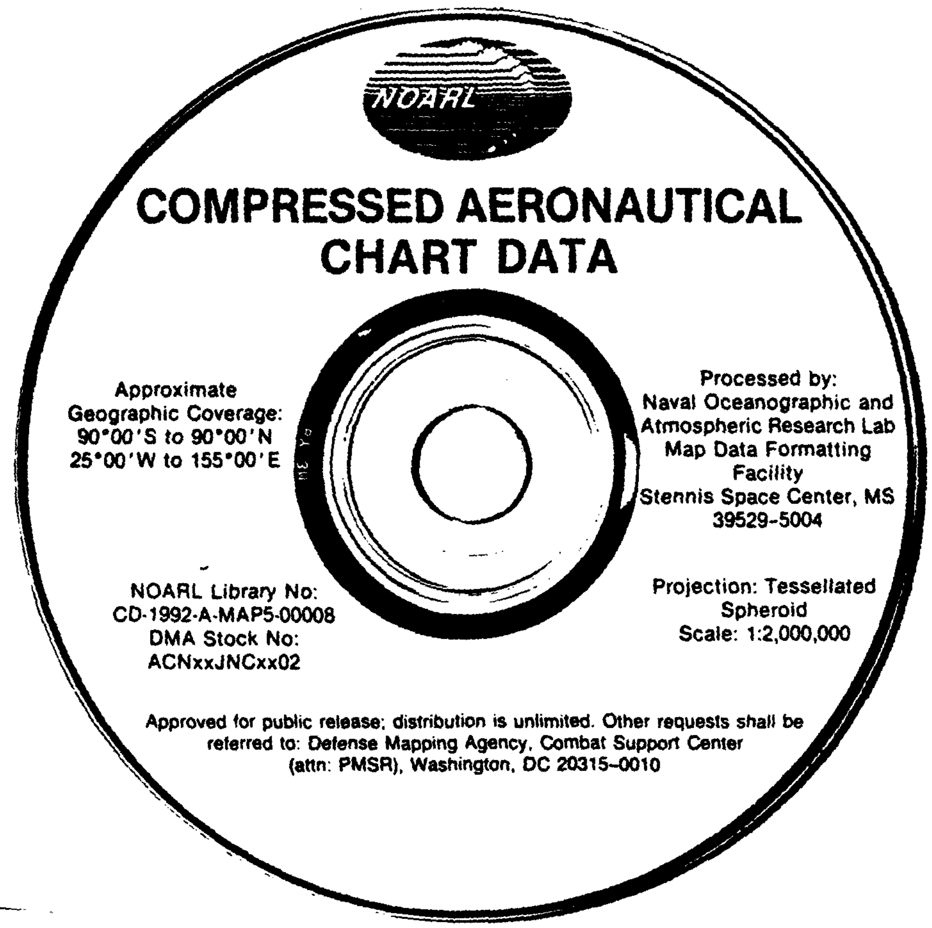
LOCATION DIAGRAM

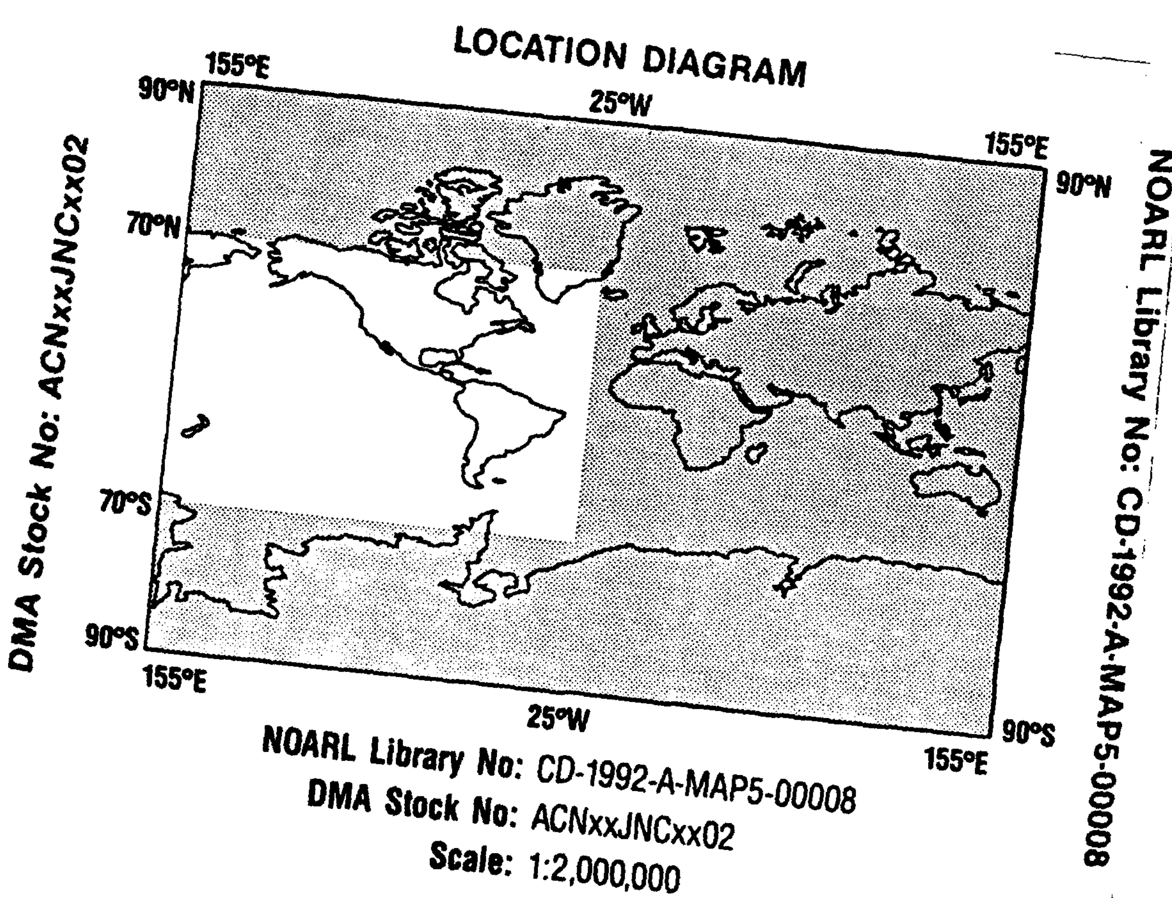


NOARL Library No: CD-1991-A-MAP3-10004
DMA Stock No: ACNxxTPCxx0506
Scale: 1:500,000

NOARL Library No: CD-1991-A-MAP3-10004

Lohrenz, Wischow, Trenchard, Riedlinger, Mehaffey, Johnson,
Tyskiewicz, Kaufman, Gendron, Myrick, Rosche.





GEOMAGNETIC JERKS AND TEMPORAL VARIATION

M. G. McLeod
Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center, MS 39529-5004

Abstract

Geomagnetic temporal variations, or time variations of Earth's magnetic field, cover a wide spectrum extending over more than 20 orders of magnitude in frequency. The spectrum extends from frequencies greater than 1000 Hz to periods of more than 100 million years. Sources of the geomagnetic field and its time variations are electric currents located both internal and external to the surface of the Earth. The major portion of this review deals with the period range 1 year to several hundred years.

Sponsored by the Office of Naval Research.

Published in the Encyclopedia of Earth System Science, Volume 2, September 1991.

(McLeod)

NOISE AND EXTERNAL SOURCE FIELDS IN MAGNETIC OBSERVATORY ANNUAL MEANS

M. G. McLeod
Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center, MS 39529-5004

Abstract

Noise and external source fields can be observed in all day annual means of vector magnetic field components measured at magnetic observatories. Data are for the time interval 1910-1983 and the observatories are widely distributed about Earth. A principal objective of the reported research has been separation of fields of internal origin from fields of external origin and from noise.

A spherical harmonic model has been fit to first differences of the magnetic observatory annual means. The method of stochastic inversion was used to determine spherical harmonic coefficients from observatory data weighted with estimated rms errors for each field component at each observatory.

Nearly all time variation due to external sources in first differences of annual means of observatory data can be modeled by odd degree zonal spherical harmonics in geomagnetic coordinates. The largest component due to external sources is of degree-one and has an rms value of 7.0 nT/yr. The induced internal source field due to time variations of the external sources is consistent with a conducting core and insulating mantle for the Earth.

Noise in observatory annual means first differences is approximately white with an rms value of 2 nT/yr for each field component at a typical observatory for the time interval 1961-1983. Noise rms values vary form 0.5 nT/yr to 30 nT/yr at different observatories and were generally larger for years prior to 1960.

Sponsored by the Office of Naval Research.

Presented at the AGU Spring Meeting, Baltimore, MD, May 28, 1991.

EXTERNAL SOURCE FIELDS IN MAGNETIC OBSERVATORY ANNUAL MEANS

M. G. McLeod
Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center, MS 39529-5004

Abstract

Fields due to external sources can be observed in all day annual means of vector magnetic field components measured at magnetic observatories. Data are for time interval 1910-1983 and the observatories are widely distributed about Earth. A principal objective of the reported research has been separation of fields of internal origin from fields of external origin and from noise.

A spherical harmonic model has been fit to first differences of magnetic observatory annual means. The method of stochastic inversion was used to determine spherical harmonic coefficients from observatory data weighted with estimated rms errors for each field component at each observatory.

Nearly all time variation due to external sources in first differences of annual means of observatory data can be modeled by odd degree zonal spherical harmonics in geomagnetic coordinates. The largest component due to external sources is of degree-one and has rms value of 7.0 nT/year. The induced internal sources field due to time variations of the external sources is consistent with a conducting core and insulating mantle for the Earth. The annual mean field due to external sources can charge by as much as 13 nT in a single year and by over 20 nT in a two year period.

Sponsored by the Office of Naval Research.

Published in proceedings from the Twentieth General Assembly of the International Union of Geodesy and Geophysics, Vienna, Austria, August 1991.

MULTISPECTRAL BATHYMETRY PROGRAMS: A USERS GUIDE

H. V. Miller
T. Green-Douglas
C. Walker
R. K. Clark
T. Fay
Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center, MS 39529-5004

Abstract

The Naval Oceanographic and Atmospheric Research Laboratory, the Navy's lead laboratory in mapping, charting, and geodesy, is currently investigating the use of remotely sensed multispectral imagery as an accurate source for computing coastal-zone bathymetry. Because the Navy supports amphibious operations, special warfare, and coastal hydrographic surveying, knowledge of near-shore features is essential. The widespread availability, temporal sensitivity, and almost complete global coverage of most satellites' imagery make it an ideal way to collect water depth information from areas of limited or denied standard access. Bathymetry computations are done through software designed specifically for the ongoing research in this field. The software applications and abilities are discussed in this technical note.

Sponsored by the Office of Naval Technology Program Element 62435N.

Published as NOARL Technical Note 95, January 1991.

AIRBORNE ELECTROMAGNETIC TECHNOLOGY

E. Mozley
Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center, MS 39529-5004

Abstract

NOARL has been developing advanced airborne electromagnetic (AEM) methods in conjunction with Geophex, Inc., Right by Design, Inc. and Lawrence Berkeley Laboratory over the last six years. A major thrust of this effort was to implement a broad band system using the latest solid state components. The results of this effort resulted in a digitally controlled system that can operate at multiple frequencies simultaneously and generate moments of 1600 A-m^2 at frequencies as low as 90 Hertz. The transmitter is designed such that it can generate an arbitrary time varying current of as much as 40 Amps.

This System has been tested on two Navy platforms (SH-3 & RH-53 helicopters) and has successfully conducted surveys that resulted in a validated root mean squared accuracy in water depths of two feet over a range of 0 to 60 feet. The system noise sources have been identified and appropriate design changes have been initiated. The source of the dominate noise component in the system is mechanical motion or vibration of the tow body. Methods to minimize this problem have been developed but require additional air tests to validate their effectiveness.

Interpretation and modeling algorithms have been developed to identify one dimensional variations (Parameters vary in depth only) and to identify areas that are characterized by rapid spatial variations (2-D & 3-D).

Sponsor: Office of Naval Technology.

Abstract for the Electromagnetics Symposium, Laurel, MD, May 29-30, 1991.

(Mozley)

KINGS BAY AIRBORNE ELECTROMAGNETIC SURVEY

Edward Mozley
Timothy Kooney
David Byman
Daniel Fraley
Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center, MS 39529-5004

Abstract

The airborne hydrography survey conducted using the Naval Oceanographic and Atmospheric Research Laboratory's new generation electromagnetic sensor system at Kings Bay has verified that this technology provides a viable means to remotely survey coastal zones. In addition to water depth, the field test clearly indicated that the system was capable of rapidly mapping water and sediment conductivities. Thus, the technique provides the Navy with a potent tool to remotely measure multiple oceanographic and geotechnical parameters that can impact mine warfare and amphibious operations.

Sponsored by Chief of Naval Operations (OP-096) under Program Element 63704N.

Submitted as a Special Project to sponsor.

AIRBORNE ELECTROMAGNETIC HYDROGRAPHIC SURVEY TECHNOLOGY

E. Mozley
T. Kooney
D. Byman
D. Fraley
Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center, MS 39529-5004

Abstract

An advanced airborne electromagnetic (AEM) hydrographic system was developed along the Atlantic Coast in southern Georgia to chart water depths and map variations in sea floor sediments. The survey consisted of three helicopter sorties and resulted in the acquisition of AEM data that had the same area coverage as two high density acoustic surveys. In addition, in-situ water temperature and conductivity . easurements were acquired over the tidal cycle in the survey area. These data sets provided the necessary information required to evaluate the capabilities of the new AEM technology.

The interpretation of the AEM survey indicated that the inferred water conductivities agreed with in-situ measurements to an accuracy of 0.1 Siemens/meter. The root mean square (RMS) difference in water depths that was provided by the AEM measurements minus the acoustic reference measurements was less than two feet. Seafloor conductivities were spatially coherent and provided realistic formation factors ranging from 3.2 to 9.5.

The results provided by this airborne hydrographic survey have verified that this technology provides a viable means to remotely survey coastal zones. In addition to water depth, the field test clearly indicated that the system was capable of rapidly mapping water and sediment conductivities. Thus, the technique provides an important tool to remotely measure multiple oceanographic and geotechnical parameters.

Sponsored by the Chief of Naval Operations (OP-096) and the Office of Naval Technology.

Presented at SEG 1991 Annual Meeting, May 1991.

ADVANCED AIRBORNE ELECTROMAGNETIC TECHNOLOGY INNOVATIVE MONITORING TECHNOLOGIES -- 91 REVIEW OF AQUATIC AND SUBSURFACE MONITORING

E. Mozley
T. Kooney
D. Byman
Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center, MS 39529-5004

Abstract

The airborne electromagnetic system (AEM) system provides the Navy with an innovative means to measure shallow water depths and electrical conductivity from a helicopter at air speeds of 85 knots. This technology provides a means that is independent of sea state to acquire a "quick look" at a hydrographic setting. This method would be very useful as a reconnaissance tool to both monitor water depths under conditions which do not permit acoustic measurements and to efficiently plan and implement acoustic surveys.

A major advantage of this technology is that it is flexible enough to operate in shallow water areas ranging from the beach through water depths in excess of 30 meters. The AEM system can map bathymetry through ice and in silt laden water with poor optical characteristics (turbid). The ability to measure soil conductivity to depths of several meters provided a remote means to map soil moisture characteristics in the subsurface through the beach zone. In addition, the ability to measure sea floor conductivities in the surf zone provides a means to map variations in sedimentary porosities.

Sponsored by CNO OP-096 under Program Element 63704N.

Presented at the U.S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory, Las Vegas, NV, February 25-28-1991.

(Mozley)

ADVANCED AIRBORNE ELECTROMAGNETIC HYDROGRAPHY

E. Mozley
T. Kooney
D. Byman
Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center MS 39529-5004

Abstract

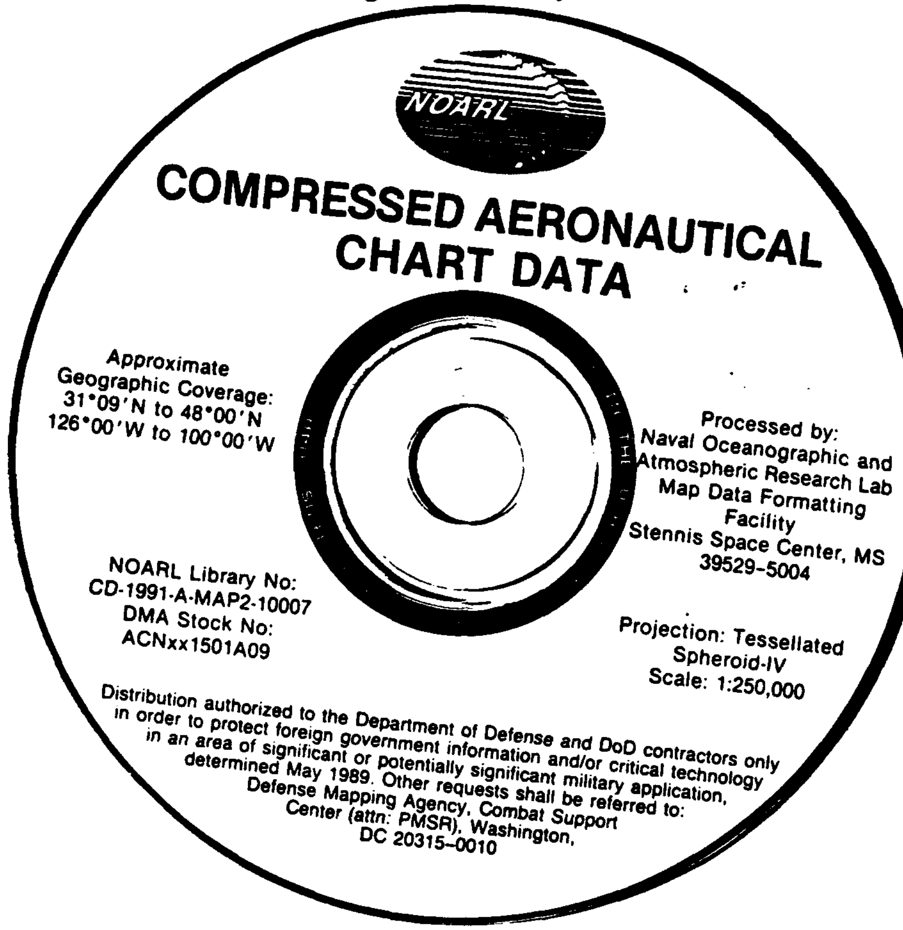
The Naval Oceanographic and Atmospheric Research Laboratory (NOARL) in conjunction with Geophex, Ltd. and Right By Design Inc. developed and tested an advanced wide band airborne electromagnetic (AEM) system that was designed to measure water depths in shallow coastal environments. The system utilizes high power MOSFET components configured in a H-bridge mode to digitally convert 500 volts DC power into an arbitrary time varying current through a transmitter loop. The system can generate moments of 1600 Amp-m" over the operational band that ranges from 90 to 5000 Hertz. The system is currently configured to operate at three selectable frequencies simultaneously and has very stable system characteristics. The baseline drift of this system is less than 15 ppm/hour. The system noise, which when averaged over 5 samples or a 1/6 second time window, varies as a function of frequency but a representative peak value in the low frequency range is 2.5 ppm over +/-15 Hertz triangular window centered at 150 Hertz.

The advanced AEM system was evaluated over the entrance channel in Kings Bay, GA to chart water depths and map variations in sea floor sediments. The survey consisted of three helicopter sorties and resulted in the acquisition of a set of high quality data that had the same areal coverage as two high density acoustic surveys. In addition water temperature and conductivity measurements were acquired along the surveyed channel throughout the tidal cycle. These data sets provided the necessary information that resulted in a quantitative evaluation of the performance of this technology.

The interpretation of the AEM data indicated that the inferred water conductivities agreed with in-situ measurements to an accuracy of 0.1 Siemens/meter. The average water depths, which were provided by the AEM system along the 5300 foot survey lines, deviated from the acoustic data by a RMS value of two feet. Seafloor conductivities were spatially coherent and provided realistic formation factors ranging from 3 to 13 that should correspond to variation in bottom material ranging from a clean consolidated sand to a poorly consolidated clay or silt.

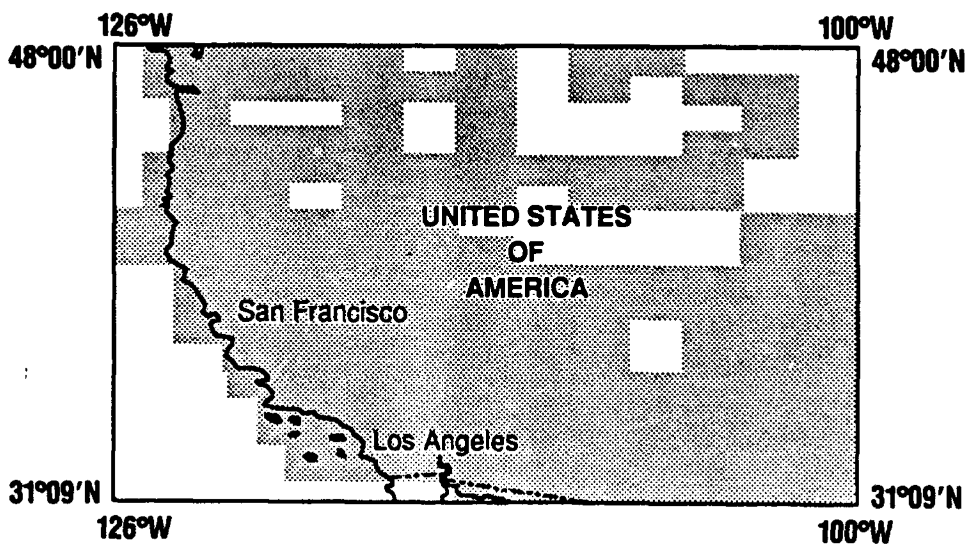
Sponsor: The hydrographic survey and system development was sponsored by the Chief of Naval Operations (OP-096) and the Office of Naval Technology. The Naval Air Systems Command provided the helicopter and ground facilities used during the field tests.

Presented at MTS '91, New Orleans, LA, November 11-13, 1991.



DMA Stock No: ACNxx1501A09

LOCATION DIAGRAM



NOARL Library No: CD-1991-A-MAP2-10007

DMA Stock No: ACNxx1501A09

Scale: 1:250,000

NOARL Library No: CD-1991-A-MAP2-10007

MDFF HELP: LIBRARY: ON-LINE DOCUMENTATION FOR THE MAP DATA FORMATTING FACILITY

S. Myrick
Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center, MS 39529-5004

Abstract

The purpose of this document is to describe on-line documentation for NOARL's Map Data Formatting Facility (MDFF). The MDFF utilizes Digital Equipment Corporation computers to process several types of data including Compressed Aeronautical Chart, Compressed Nautical Chart, and Digital Landmass System. Using DEC software utilities, on-line documentation has been developed that provides information pertaining to the processing and compression of these data types and to other topics that are specific to the MDFF.

Sponsor: The MDFF project is funded by the Naval Air Systems Command, offices of the AV-8B (program element 64214), F/A-18 (APN), V-22 (program element 64262) and A-X (program element 64233) programs.

Published as NOARL Technical Note 211.

DATA BASE DESIGN DOCUMENT FOR THE DIGITAL MAP COMPUTER SOFTWARE IN THE A-12 DIGITAL MAP SET

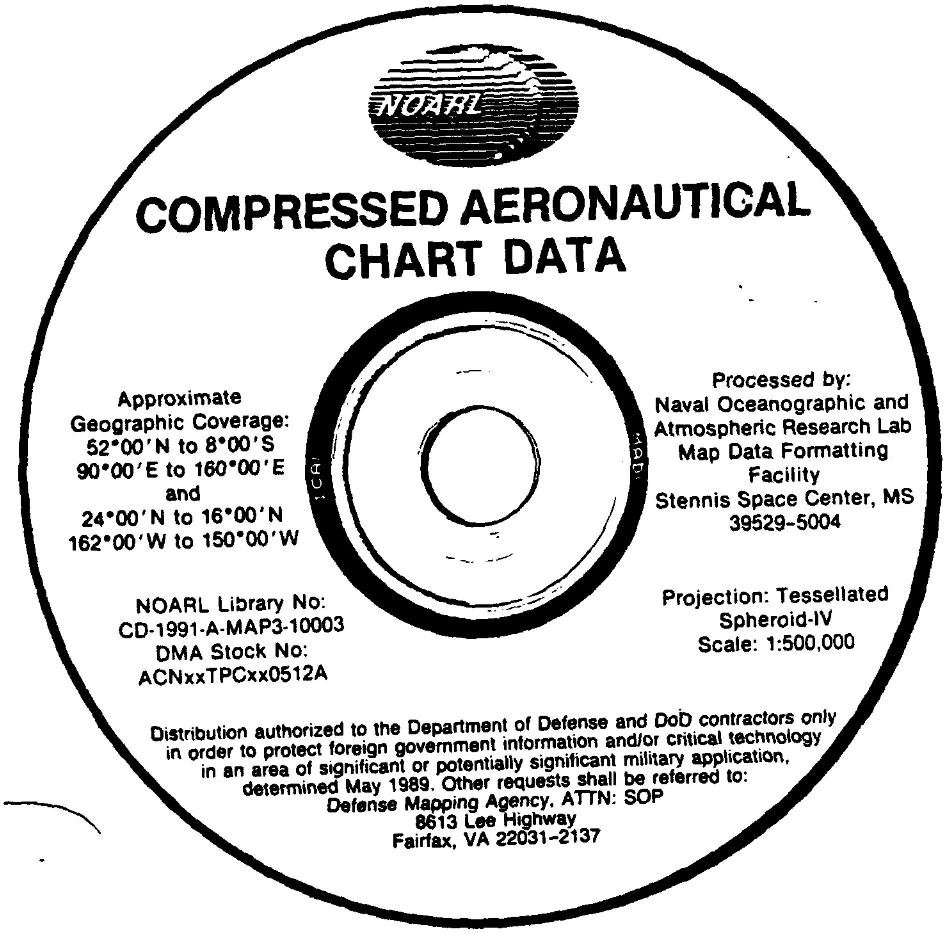
S. Myrick
M. Lohrenz
Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center, MS 39529-5004

Abstract

The purpose of this Data Base Design Document is to describe the content and format of the A-12 Digital Map Set Data Base (Harris document number 801979) as seen by the A-12 Digital Map Computer, Computer Software Configuration Item, (Harris document number 801970) of the Digital Map Set (Harris document number 174514) System. The A-12 Digital Map Set Data Base also contains files that have previously defined by McDonnell Douglas; therefore, this document does not describe those files in detail. Modification of this document is part of a NOARL effort to provide the Fleet with documentation and mapping products that comply with Navy standards.

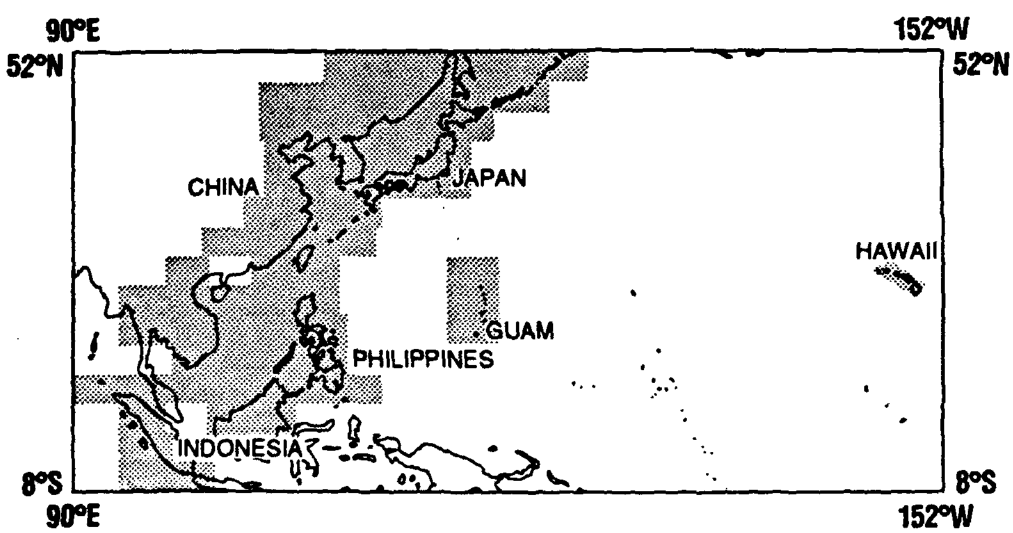
Sponsor: Funded by the Naval Air Systems Command under Program Element 94010 (0604233N).

Published as NOARL Technical Note 162, August 1991.



LOCATION DIAGRAM

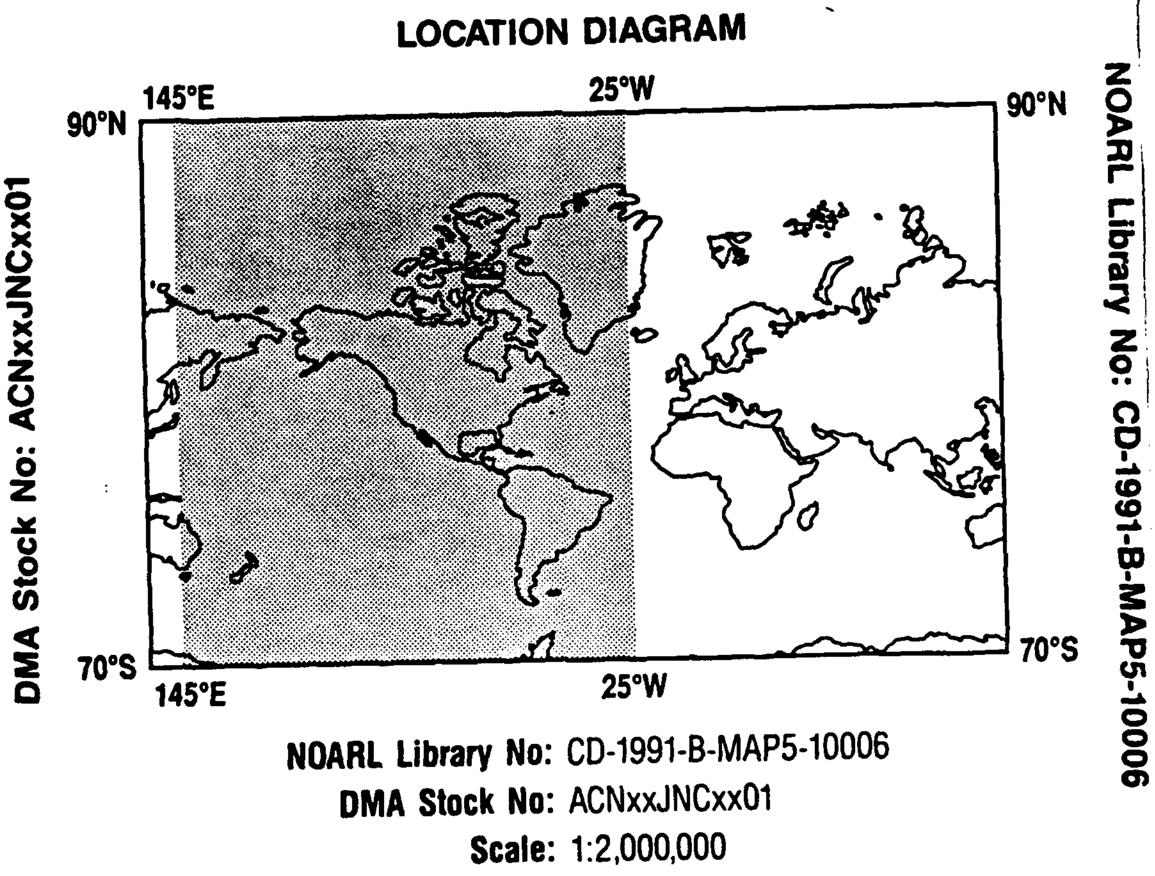
DMA Stock No: ACNxxTPCxx0512A



NOARL Library No: CD-1991-A-MAP3-10003

NOARL Library No: CD-1991-A-MAP3-10003
DMA Stock No: ACNxxTPCxx0512A
Scale: 1:500,000


NOARL
COMPRESSED AERONAUTICAL
CHART DATA
Approximate
Geographic Coverage:
70°00'S to 90°00'N
145°00'E to 25°00'W
Processed by:
Naval Oceanographic and
Atmospheric Research Lab
Map Data Formatting
Facility
Stennis Space Center, MS
39529-5004
NOARL Library No:
CD-1991-B-MAP5-10006
DMA Stock No:
ACNxxJNCxx01
Projection: Tessellated
Spheroid-IV
Scale: 1:2,000,000
Distribution authorized to the Department of Defense and DoD contractors only
in order to protect foreign government information and/or critical technology
in an area of significant or potentially significant military application,
determined May 1989. Other requests shall be referred to:
Defense Mapping Agency, Combat Support
Center (attn: PMSR), Washington,
DC 20315-0010


LOCATION DIAGRAM
145°E
25°W
90°N
90°N
70°S
70°S
145°E
25°W
DMA Stock No: ACNxxJNCxx01
NOARL Library No: CD-1991-B-MAP5-10006
NOARL Library No: CD-1991-B-MAP5-10006
DMA Stock No: ACNxxJNCxx01
Scale: 1:2,000,000

BACK PROPAGATION NEURAL NETWORKS FOR BATHYMETRY MODELING USING MULTISPECTRAL DATA

H. Rosche III
Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center, MS 39529-5004

Abstract

This presentation describes the methods and results of attempts to model bathymetry data using back-propagation neural networks. Water depths are taken from charts calibrated to the nearest fathom and converted to meters. Landsat Thematic mapper data is assigned to these depth values to serve as the raw data. The raw data is then split into two groups. The first group serves as the training set for the neural network. The second set, which serves as the control set, is held aside as a means of determining whether the network learned the depth functions or just memorized the initial data. Results and structures are briefly described in these session notes.

Sponsored by the Naval Air Systems Command, Program Element #94010.

Presented at U.S. DECUS 1991 Spring Atlanta Symposium, Atlanta, GA, May 6-10, 1991.

(Rosche)

IMAGE COLOR REDUCTION AND ITS APPLICATIONS TO DIGITAL DATA

H. Rosche III
Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center, MS 39529-5004

Abstract

Many image applications today require the display of digital data with more bits than are available on the display hardware. Whether this data is 8-bits of red, green and blue (24-bit) or a color compressed data set where eight bits serve as an index into a color palette both may benefit from color reduction. Within red, green and blue space there are more than 16 million possible colors. However, the human eye can perceive only about 350,000 distinct colors. Using this information, image colors may be compared to the other colors in the image and those that are sufficiently close and of the same hue may be removed and replaced with their counterpart. The advantage of this approach has several possibilities. When using PC's with limited color capabilities (16 to 256 colors) this allows more colors to be chosen producing a better image with less color information loss. If the image is to be compressed by some method then having less colors in the image results in a higher degree of compression and less storage space. Finally, considerations governing color distance criteria and hue boundary exceptions are covered.

Sponsor: This work was sponsored by NAVAIR and is funded by the AV-8B, F/A-18, V-22, and A-12 programs under Aircraft Procurement, Navy H1CC, program elements 9410101 (64262N) and 980101 (APN).

Presented at the U.S. DECUS 1991 Spring Atlanta Symposium, Atlanta, GA, May 1991.

(Rosche)

DIGITAL DATA COMPRESSION USING VECTOR QUANTIZATION AND DOUBLE COLOR SPACE NORMALIZATION

H. Rosche III
M. Lohrenz
M. Trenchard
Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center, MS 39529-5004

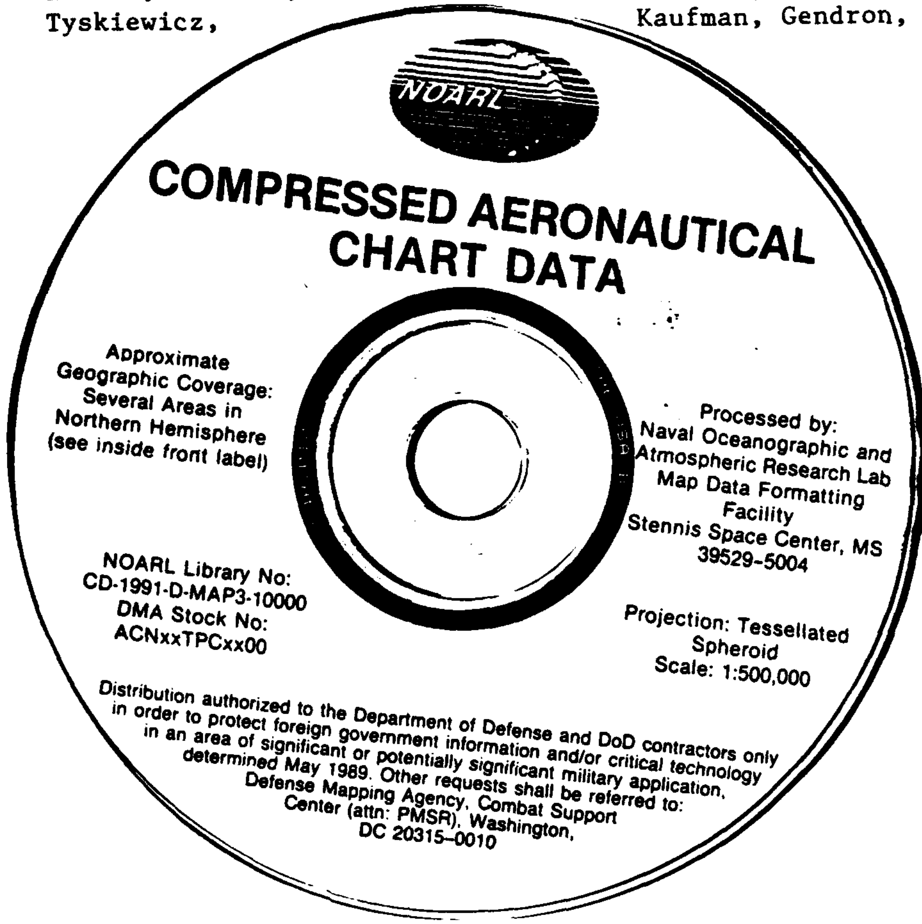
Abstract

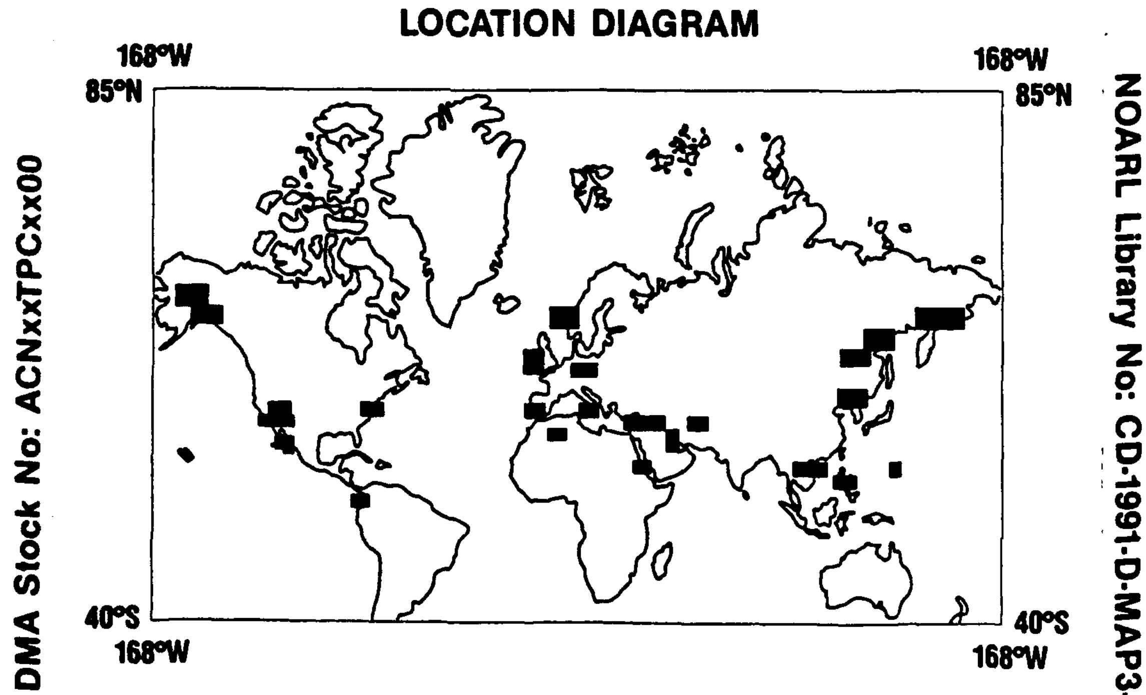
The Naval Oceanographic and Atmospheric Research Laboratory's (NOARL) Map Data Formatting Facility (MDFF) is developing improved methods of compressing full-color (24-bit) aeronautical chart images. The original MDFF compression method consists of two stages. In the first stage, color compression, the 240 most representative colors in an image are identified and entered in an 8-bit color lookup table. Each 24-bit pixel (8 bits each of red, green, and blue) in the image is then replaced with one of the 8-bit values in the table, for a compression of 3:1. In the second stage, the image is spatially compressed by replacing each non-overlapping square of 2x2 pixels with a 1-byte codeword, for an additional 4:1 compression. A total of 256 codewords are stored with their four corresponding pixel values in a codebook file. This paper describes a new method in which 4x4 pixel sets (rather than the original 2x2 pixel sets) are replaced by codewords in the spatial compression stage, achieving an 8:1 compression. The first stage of color compression remains the same. This new method achieves a total compression ration of 48:1 (3:1 color and 16:1 spatial) when using 8-bit codebook lookup values or 24:1 (3:1 color and 8:1 spatial) when using 16-bit codebook lookup values.

Sponsor: This work is sponsored by the Naval Air Systems Command and funded by the AV-8B, F/A-18, V-22, and A-12 programs under Aircraft Procurement, Navy H1CC, program elements 9410101 (64262N) and 980101 (APN).

Presented at the IEEE Data Compression Conference, Snowbird, Utah, April 8-11, 1991.

(Rosche) Rosche, Lohrenz, Wischow, Trenchard, Riedlinger, Mehaffey, Johnson, Tyskiewicz, Kaufman, Gendron, Myrick

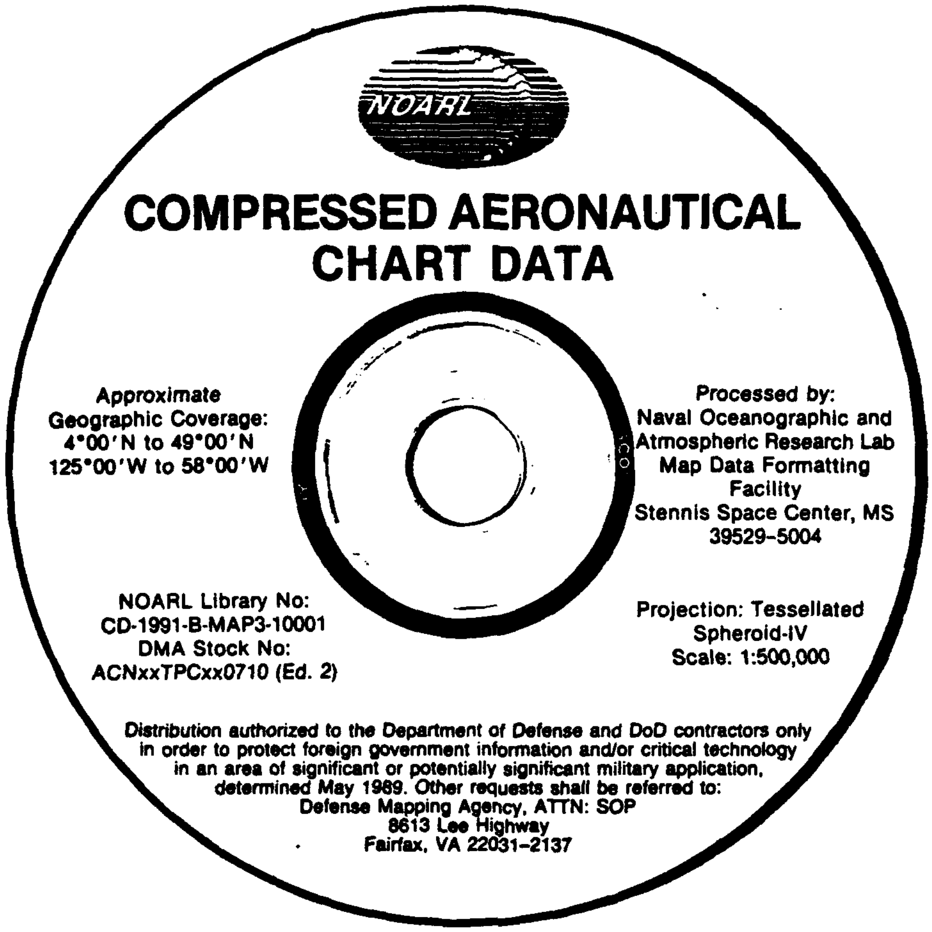




NOARL Library No: CD-1991-D-MAP3-10000
DMA Stock No: ACNxxTPCxx00
Scale: 1:500,000

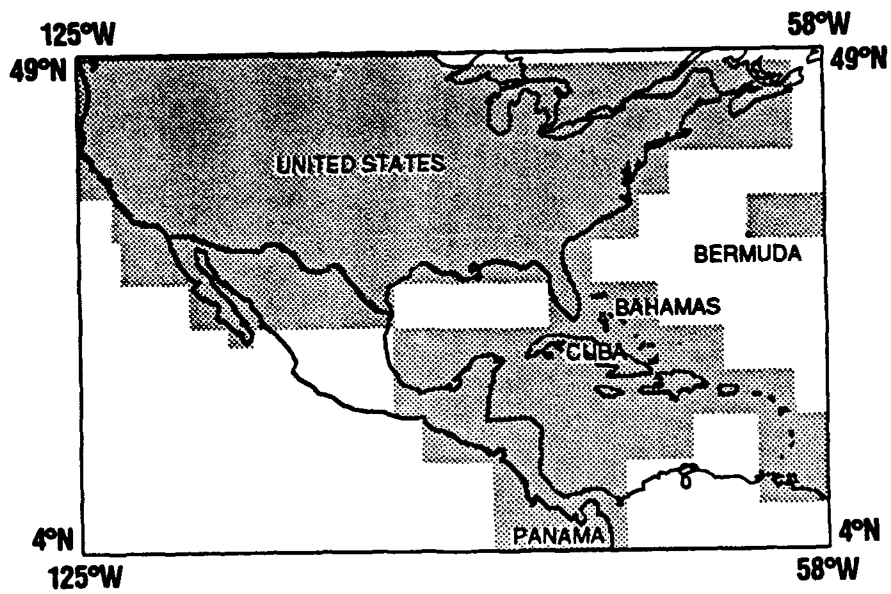
(Rosche)

Rosche, Briggs, Lohrenz,
Wischow, Trenchard, Riedlinger



DMA Stock No: ACNxxTPCxx0710 (Ed. 2)

LOCATION DIAGRAM



NOARL Library No: CD-1991-B-MAP3-10001
DMA Stock No: ACN xTPCxx0710 (Ed. 2)
Scale: 1:500,000

NOARL Library No: CD-1991-B-MAP3-10001

(Shaw)

AN ANALYSIS OF NAVY DIGITAL MC&G REQUIREMENTS

K. Shaw
D. Byman
S. Carter
M. Harris
M. Kalcic
M. Clawson
Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center, MS 39529-5004

Abstract

During 1991 an extensive digital MC&G (dMC&G) requirements study was conducted by NOARL in order to accurately portray current and projected Navy usage of dMC&G. Over 100 programs responded to a distributed questionnaire. An analysis of the collected data is presented with an emphasis on the following areas: current Navy dMC&G usage of existing DMA and non-DMA products, contractor involvement, simulators and trainers, government-owned and available dMC&G product software, state of the formal requirements process, lessons learned from Operation Desert Storm, and detected dMC&G product deficiencies. Some key findings from this analysis include: contractors are performing more dMC&G product modifications than government agencies, many dMC&G requirements are not being addressed early on in the program life cycle through the acquisition process, and 162 available software routines that are used on dMC&G products have been identified.

Sponsored by the Oceanographer of the Navy under Program Element 63704N.

Presented at the DoD MC&G Conference, Washington, DC, October 1991.

A SUMMARY OF THE COLLECTED DATA FROM A SURVEY OF NAVY DIGITAL MC&G REQUIREMENTS

K. Shaw
D. Byman
S. Carter
M. Kalcic
M. Clawson
M. Harris
Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center, MS 39529-5004

Abstract

NOARL conducted an extensive digital Mapping, Charting and Geodesy (dMC&G) requirements study (1991) in order to accurately portray current and projected Navy usage of dMC&G products. Over 100 programs responded to a distributed questionnaire, and provided detailed information about their use of dMC&G products. This document presents a summary of the collected data. A complete analysis of the data, along with recommendations to improve the Navy's usage of dMC&G, will be performed in a detailed follow-on report.

Sponsored by the Oceanographer of the Navy under Program Element 63704N within the DMAP program.

Published as NOARL Technical Note 197, November 1991.

(Terrie)

MODELING GLOBAL SOLAR SURFACE IRRADIANCE

G. Terrie
R. Arnone
Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center, MS 39529-5004

R. Oriol
Planning Systems Incorporated
Slidell, LA 70458

Abstract

A model has been developed which calculates the monthly total surface solar irradiance incident at the ocean surface. The model assimilates the Total Ozone Mapping Spectrometer (TOMS) database and the Coastal Zone Color Scanner (CZCS) Goddard 20 Km database for determination of the ozone optical thickness and aerosol optical thickness. The model determines the spectral (400 - 700 nanometer) solar transmission through the atmosphere accounting for rayleigh scattering (T_r), ozone (T_o) and aerosol (T_a) thicknesses, and water vapor (T_w).

The TOMS database, which provides a daily ozone distribution for each ocean location, is monthly averaged to determine the ozone optical thickness. Additionally, the mean monthly radiance, La670 from the CZCS database, represents an estimate of the atmospheric aerosol thickness for each location. These average monthly atmospheric transmission parameters are computed with the time of day and the solar zenith angle to define the diffuse and vector surface solar irradiance at 490 nanometer wavelength. The calculations are repeated for a 24 hour day to determine monthly composite images of the solar irradiance which are coincident with the CZCS bio-optical composites.

Model results over the North Atlantic region for 1979 are presented. Monthly and seasonal changes in the solar irradiance are clearly evident. The solar irradiance is shown to be significantly influenced by the aerosol concentrations. Estimates of the temporal and spatial variability of the solar irradiances are influential on the biological processes occurring in the surface ocean.

Sponsored by the Oceanographer of the Navy, Program Element #63704N.

Presented at the AGU Spring Meeting, Baltimore, MD, May 1991.

(Terrie)

VARIABILITY OF SOLAR IRRADIANCE AT THE OCEAN SURFACE

G. Terrie
R. Arnone
Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center, MS 39529-5004

R. Oriol
Planning Systems Incorporated
Slidell, LA 70458

Abstract

An atmospheric model has been developed which calculates the monthly total surface solar irradiance incident at the ocean surface. Monthly model results over the North Atlantic region for 1979 illustrate significant spatial variability of the solar irradiance. Solar irradiance is shown to be significantly influenced by cloud cover and aerosol concentration and, to a lesser extent, by ozone concentration. Estimates of this climatic variability of the solar irradiances are influential on the global biological processes occurring at the ocean surface.

The model assimilates the mean monthly Total Ozone Mapping Spectrometer (TOMS) database, the Coastal Zone Color Scanner (CZCS) database, and an Air Force cloud cover climatic database for determination of ozone optical thickness, aerosol optical thickness, and percent cloud cover, respectively. The model first computes the clear sky irradiance at 490 nanometers (nm) at the sea surface, at hourly time steps, for a one month period accounting for Rayleigh scattering, ozone and aerosol thicknesses, and water vapor and uniform gas concentrations. The irradiance is then corrected for cloud cover.

Sponsored by Space and Naval Warfare Systems Command.

Presented at MTS '91, November 11-13, 1991, New Orleans, LA.

DIGITAL MAP PRODUCTS IN SUPPORT OF AVIONIC DISPLAY SYSTEMS

M. Trenchard
M. Lohrenz
H. Rosche III
P. Wischow
Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center, MS 39529-5004

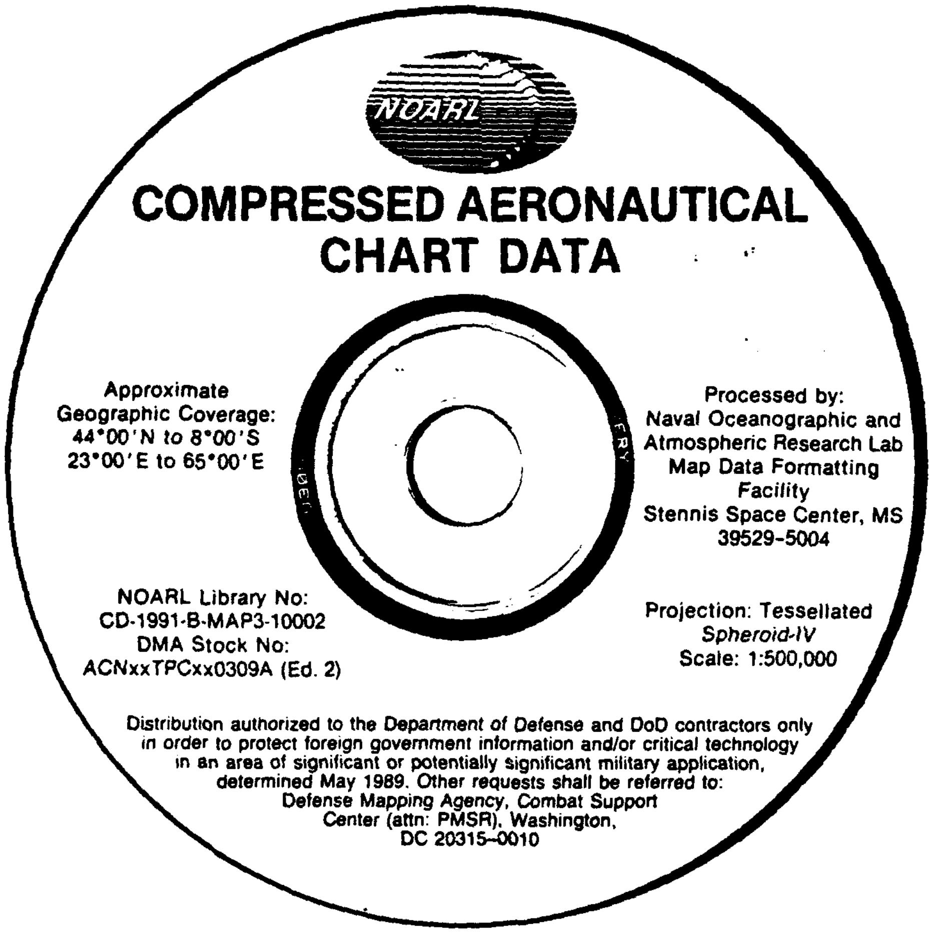
Abstract

The emergence of computerized mission planning systems (MPS) and airborne digital moving map systems (DMS) has necessitated the development of a global database of raster aeronautical chart data specifically designed for input to these systems. The Naval Oceanographic and Atmospheric Research Laboratory's (NOARL) Map Data Formatting Facility (MDFF) is presently dedicated to supporting these avionic display systems with the development of the Compressed Aeronautical Chart (CAC) database and development of aircraft-specific, Write-Once, Read Many (WORM) optical disks. NOARL has also initiated a comprehensive research program aimed at improving the pilots' moving map displays; current research efforts include the development of an alternate image compression technique and generation of a standard set of color palettes.

The CAC database will provide digital aeronautical chart data in six different scales. CAC is derived from the Defense Mapping Agency's (DMA) Equal Arc-second (ARC) Digitized Raster Graphics (ADRG), a series of scanned aeronautical charts. NOARL processes ADRG to tailor the chart image resolution to that of the DMS display while reducing storage requirements through image compression techniques. CAC is being distributed by the DMA as a library of CDROMs.

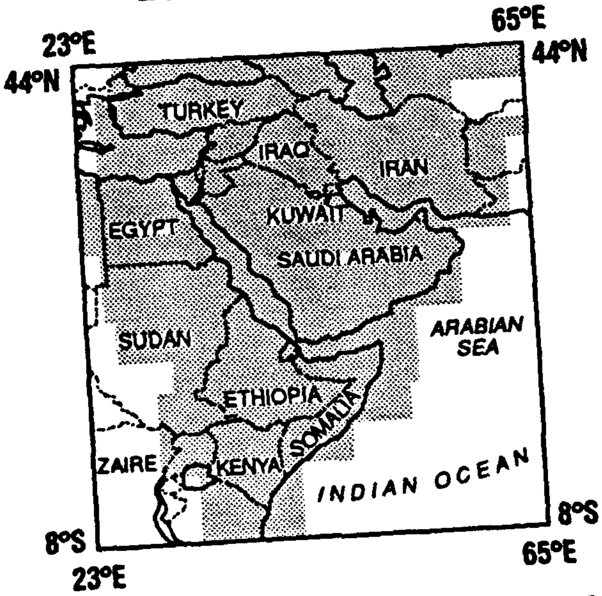
Sponsor: This work was sponsored by the Naval Air Systems Command (NAVAIR) and is funded by the AV-8B, F/A-18, V-22, and A-12 programs under Aircraft Procurement, Navy H1CC, program elements 9410101 (64262N) and 980101 (APN).

Presented at the 1991 SPIE/SPSE Symposium on Electronic Imaging Science and Technology, San Jose, CA, 24 February - 1 March 1991.



DMA Stock No: ACNxxTPCxx0309A (Ed. 2)

LOCATION DIAGRAM



NOARL Library No: CD-1991-B-MAP3-10002
DMA Stock No: ACNxxTPCxx0309A (Ed. 2)
Scale: 1:500,000

NOARL Library No: CD-1991-B-MAP3-10002

(Walker)

EFFECTS OF FINITE SPECTRAL BANDWIDTH IN MULTISPECTRAL OPTICAL BATHYMETRY

C. Walker
Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center, MS 39529-5004

Abstract

Optical, multispectral remote sensing data from satellite and aircraft can be used to determine depths in shallow, clear waters. The physical principle used to calculate depths from received irradiances is based on the exponential attenuation of the light as a function of distance travelled through the water and the reflectivity of the bottom, both as a function of wavelength. An underlying, often unstated, assumption made is that the variation of attenuation and bottom reflectivity across a sensor spectral band (typically 60 to 80 nanometers for Landsat Thematic Mapper) can be ignored and that the irradiance measurement is valid at the band center. A more realistic simple model for a finite bandwidth sensor is derived in this paper using a piece-wise linear approximation. Using this model the limitations of conventional log-linear regression models for multispectral bathymetry are investigated. The primary conclusion is that for typical expected variations in attenuation and reflectivity as a function of wavelength, a multiband, log-linear regression model can be used for bathymetry calculations. However, straight-forward identification of the physical parameters (attenuation coefficient, bottom reflectivity) is valid.

Sponsor: Office of Naval Technology.

Presented at MTS '91, New Orleans, LA, November 11-13, 1991.

(Walker)

MULTISPECTRAL IMAGERY SUPPORT FOR LOCATION OF HAZARDS TO NAVIGATION

C. Walker
M. Kalcic
Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center, MS 39529-5004

B. Ray
Planning Systems Incorporated
Slidell, LA 70458

Abstract

The purpose of this task was to support a NAVOCEANO hydrographic survey in the Persian Gulf by providing multispectral imagery (MSI) data for use in the detection of navigational hazards and to determine the usefulness of such products in future surveys. NAVOCEANO requested NOARL produce a chart based on MSI from LANDSAT thematic mapper (TM) satellite data of the Persian Gulf area north of the United Arab Emirates in the vicinity of Jazirat Dalma for technology demonstration and evaluation.

The development of an MSI chart was divided into three stages. The first stage was to obtain and process raw satellite imagery of the desired operating area. This was done with the ERDAS image processing system using standard image processing procedures along with specially developed techniques. The second stage entailed the production and distribution of a chart suitable for operational use. The final stage will be the evaluation of the chart by survey participants and from ground truth data derived from the survey.

The fleet's need for greater application of MSI would be best met by continued interaction between NOARL, NAVOCEANO, and operating units. NOARL involvement in another exercise similar to this one would serve as an ideal vehicle for further development of MSI products which could be integrated into hydrographic survey.

Sponsored by the Naval Oceanographic Office, Hydrographic Department.

Published as a Special Report for the Naval Oceanographic Office.

THE APPLICATION OF NOARL'S AERONAUTICAL CHART COMPRESSION TECHNIQUES TO NAUTICAL CHART DATA

P. Wischow
M. Lohrenz
M. Trenchard
Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center, MS 39529-5004

Abstract

The Map Data Formatting Facility (MDFF) at the Naval Oceanographic and Atmospheric Research Laboratory (NOARL) is creating a library of Compressed Aeronautical Chart (CAC) data on Compact Disk-Read Only Memory (CD-ROM) for the Navy and the Marine Corps. The CAC is a seamless database that is created by color and spatially compressing Defense Mapping Agency (DMA) Arc Digitized Raster Graphics (ADRG) aeronautical chart data.

The CAC CD-ROMs are used for mission planning and flight operations, but they are not flown in the aircraft as the media is much too fragile to handle the typical flight environment.

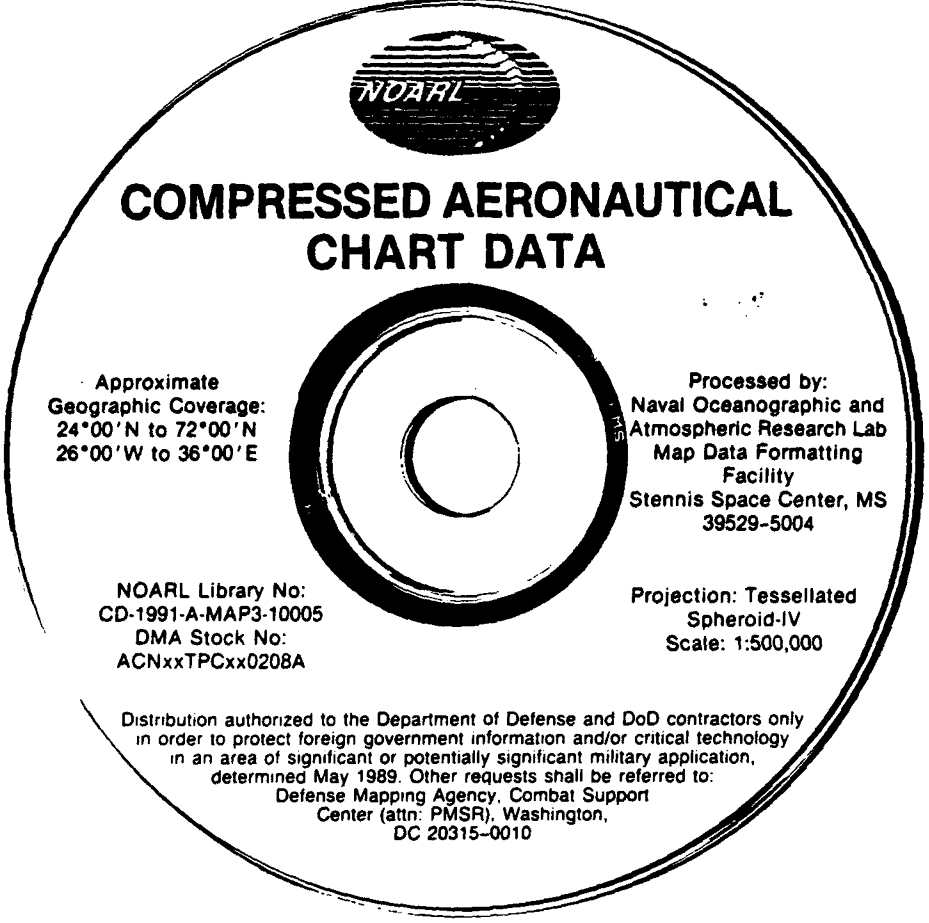
Specifically, the CAC provides direct support to the Navy's AV-8B and F/A-18 mission planning systems (MPS). The MPS extracts the compressed chart data from CD-ROM and loads it onto a militarized WORM (Write Once, Read Many) aircraft optical disk (AOD). The AOD is flown onboard the aircraft as a replacement for traditional paper charts and filmstrip products.

Since the installation of the MDFF processing suite in March, 1990, eleven CAC CD-ROM's have been produced (see Appendix A). Six CD-ROMs are current, three were pressed for internal testing, and two have been superseded due to required changes in color palettes.

In early August, 1990, the MDFF began processing ADRG data to create a CAC CD-ROM for the Desert Shield area of the Middle East (see Appendix A for geographic coverage of CAC 2B). This data was used successfully by F/A-18 and AV-8B pilots during Operation Desert Shield/Storm. These digital charts enabled the pilots to fly missions in areas of low visibility (due to oil fires, during night attack mission, etc.) with significant precision.

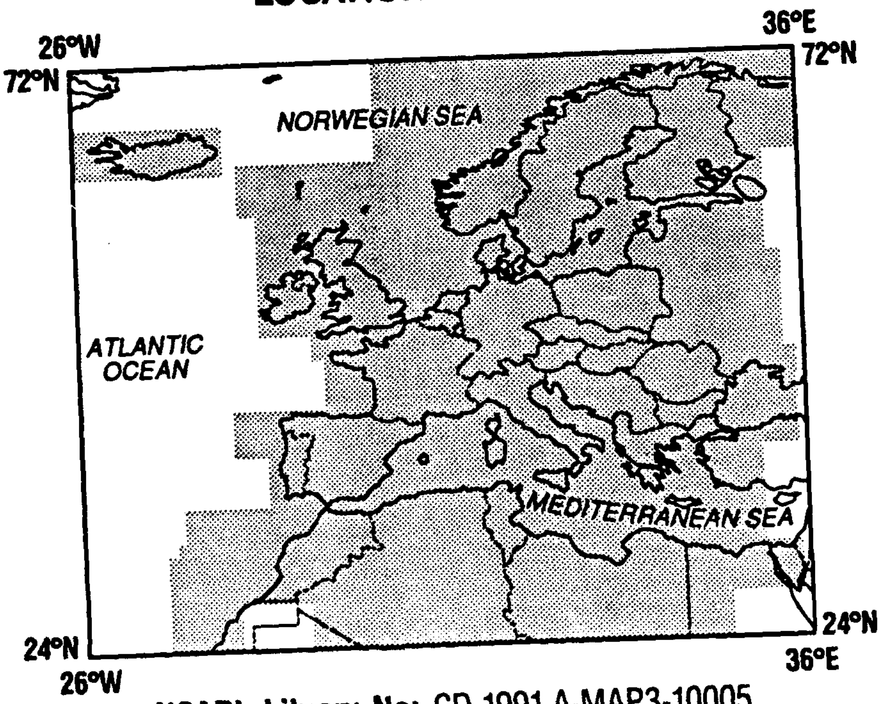
Sponsor: This work is sponsored by the Naval Air Systems Command (NAVAIR) and has been funded for the past six years by the AV-8B, F/A-18, and V-22 programs under Aircraft Procurement, Navy H1CC, program elements 940101 (64214N and 64262N) and 980101 (APN).

Presented at MTS '91, New Orleans, LA, November 11-13, 1991.



LOCATION DIAGRAM

DMA Stock No: ACNxxTPCxx0208A



NOARL Library No: CD-1991-A-MAP3-10005

NOARL Library No: CD-1991-A-MAP3-10005
DMA Stock No: ACNxxTPCxx0208A
Scale: 1:500,000

Distribution List

Commanding Officer
Naval Research Laboratory
Washington, DC 20375

Commanding Officer
Naval Research Laboratory
Attn: Library (2)
Washington, DC 20375

Officer in Charge
Naval Research Laboratory
Stennis Space Center, MS 39529-5004

Officer in Charge
Naval Research Laboratory
Code 101
Stennis Space Center, MS 39529-5004

Officer in Charge
Naval Research Laboratory
Code 110
Stennis Space Center, MS 39529-5004

Officer in Charge
Naval Research Laboratory
Code 111
Stennis Space Center, MS 39529-5004

Officer in Charge
Naval Research Laboratory
Code 113
Stennis Space Center, MS 39529-5004

Officer in Charge
Naval Research Laboratory
Code 114
Stennis Space Center, MS 39529-5004

Officer in Charge
Naval Research Laboratory
Code 115
Stennis Space Center, MS 39529-5004

Officer in Charge
Naval Research Laboratory
Code 125L (10)
Stennis Space Center, MS 39529-5004

Officer in Charge
Naval Research Laboratory
Code 125P
Stennis Space Center, MS 39529-5004

Officer in Charge
Naval Research Laboratory
Code 200
Stennis Space Center, MS 39529-5004

Officer in Charge
Naval Research Laboratory
Code 300
Stennis Space Center, MS 39529-5004

Officer in Charge
Naval Research Laboratory
Code 311
Stennis Space Center, MS 39529-5004

Officer in Charge
Naval Research Laboratory
Code 400
Monterey, CA 93943-5006

Assistant Secretary of the Navy
Research, Development, and
Acquisition
Navy Department
Washington, DC 20350-1000

Chief of Naval Operations
Attn: OP-71
OP-987
Department of the Navy
Washington, DC 20350-2000

Commander
Naval Air Systems Command
Naval Air Systems Command
Headquarters
Washington, DC 20361-0001

Commander
Naval Oceanography Command
Stennis Space Center, MS 39529-5000

Commander
Carderock Division
Naval Surface Warfare Center
Bethesda, MD 20084-5000

Commander
Naval Air Development Center
Warminster, PA 18974-5000

Commander
Naval Facilities Engineering
Command
200 Stovall St.
Alexandria, VA 22332-2300

Commander
Naval Command Control and
Ocean Surveillance Center
RDT&E Division
San Diego, CA 92152-5000

Commander
Naval Sea Systems Command
Naval Sea Systems Command HQ
Washington, DC 20362-5101

Commander
Naval Surface Warfare Center
Dahlgren, VA 22448-5000

Commander
Naval Underwater Systems Center
Newport, RI 02841-5047

Commander
Space and Naval Warfare
Systems Command
Director of Navy Laboratories
SPAWAR 005
Washington, DC 20363-5100

Commanding Officer
Naval Oceanographic Office
Attn: Library (2)
Stennis Space Center, MS 39529-5001

Commanding Officer
Naval Civil Engineering Laboratory
Port Hueneme, CA 93043

Commanding Officer
Fleet Antisub Warfare Training
Center Atlantic
Naval Station
Norfolk, VA 23511-6496

Commanding Officer
Fleet Numerical Oceanography
Center
Monterey, CA 93943-5005

Commanding Officer
Coastal Systems Station Dahlgren Division
Panama City, FL 32407-5000

Commanding Officer
Officer of Naval Research
ONR European Office
PSC 802 Box 39
FPO AE 09499-0700

Director
Defense Mapping Agency
Systems Center
Code SGWN
12100 Sunset Hill Rd #200
Reston, VA 22090-3207

Director of Navy Laboratories
Rm 1062, Crystal Plaza #5
Department of the Navy
Washington, DC 20360

Director
Office of Naval Research
Codes 10, 10D, 10P
12, 112
800 N. Quincy St.
Arlington, VA 22217-5000

Director
Office of Naval Technology
Codes 20, 234
800 N. Quincy St.
Arlington, VA 22217-5000

Director
Woods Hole Oceanographic Institute
P.O. Box 32
Woods Hole, MA 02543

Director
Defense Mapping Agency
Code PRN, Mailstop A-13
8613 Lee Hwy.
Fairfax, VA 22031-2138

Superintendent
Naval Postgraduate School
Monterey, CA 93943

Applied Physics Laboratory
Johns Hopkins University
Johns Hopkins Road
Laurel, MD 20707

Applied Physics Laboratory
University of Washington
1013 NE 40th St.
Seattle, WA 98105

Officer in Charge
Naval Undersea Warfare Center
Detachment
New London, CT 06320

Officer in Charge
Naval Surface Warfare
Center Detachment Silver Spring
White Oak Laboratory
Attn: Library
10901 New Hampshire Ave.
Silver Spring, MD 20903-5000

Applied Research Laboratory
Pennsylvania State University
P.O. Box 8029
Austin, TX 78713-8029

University of California
Scripps Institution of Oceanography
P.O. Box 6049
San Diego, CA 92166-6049

National Ocean Data Center
1825 Connecticut Ave., NW
Universal Bldg. South, RM. 206
Washington, DC 20235

Gerald Behm
Naval Explosives Ordnance Disposal
Technology Center
Code 601D
Indian Head, MD 20640-5070

Landry Bernard
Technical Director
Naval Oceanographic Office
Stennis Space Center, MS 39529

Kevin Brown
Defense Mapping Agency Sys Ctr
Code SGE
8613 Lee Highway
Fairfax, VA 22031-2138

CDR Lee Bounds
Code 228
Office of Naval Technology
800 N. Quincy Street
Washington, DC 22217-5000

CAPT Tom Callaham
Chief of Naval Operations
(OP-096)
Department of the Navy
Washington, DC 20350-1000

Doug Carl
Defense Mapping Agency Systems Center
(SG)
12100 Sunset Hill Rd #200
Reston, VA 22090-3207

Edward Chaika
Director, Office of Naval Research
Detachment
Stennis Space Center, MS 39529

Capt. Jack Chenevy
Naval Air Systems Command
Code AIR05116F
1421 Jefferson Davis Hwy.
JP2 Room 1214
Washington, DC 20361-5110

LCDR Chris Cleaver
Naval Air Systems Command
Code 546D2E1
Washington, DC 20361-5460

LtCol Russell Currer
Naval Air Systems Command
Code AIR-5117F
Washington, DC 20361-5110

Hank Fleming
Naval Research Laboratory
Code 5110
Washington, DC 20375-5000

Kim Gebhardt
Headquarters, Defense Mapping Agency
Code PRN
8613 Lee Highway
Fairfax, VA 22031-2138

Ego Hashimoto
Chief of Naval Operations
Navy Department
Pentagon, Room 4D534
Washington, DC 20350-2000

Max Houck
Space and Naval Warfare Systems
Command
PMW-185K
Washington, DC 20363-5000

Dr. Thomas Kinder
Office of Naval Research
Code 1122ML
800 North Quincy Street, #1
Arlington, VA 22217-5000

CDR Tom Klocek
Defense Mapping Agency Systems
Center
12100 Sunset Hill Rd #200
Reston, VA 22090-3207

Dan Morris
CINCPACFLT MC&G Office
U.S. Pacific Flt C-02M
Pearl Harbor, HI 96860

Major Art Nalls
Naval Air Systems Command
Code AIR-5117F
Washington, DC 20361-5110

Mike Pastore
Atmospheric Science Directorate
Naval Research Laboratory - Monterey
Monterey, CA 93943

Keith Plumadore
Naval Explosives Ordnance Disposal
Technology Center
Code 601D
Indian Head, MD 20640-5070

LCDR Don Potter
Defense Mapping Agency
Attn: Code PRR
8613 Lee Hwy.
Fairfax, VA 22031-2138

CDR Michael D. Redshaw
Naval Air Systems Command
Code AIR-5115X
1421 Jefferson Davis Highway
Washington, DC 20361-5115

Major Mike Ronner
Intelligence Center
Marine Corps Combat Development
Center
Quantico, VA 22134

Dave Scopp
Defense Mapping Agency Systems Center
(SG)
12100 Sunset Hill Rd #200
Reston, VA 22090-3207

Major J. P. Stevens
Naval Air Systems Command
Code PMA-265-32
Program Executive Officer
Tactical Aircraft Programs
Washington, DC 20361-1010

Steve Von Christierson
Space and Naval Warfare Systems
Command (PMW-185)
Washington, DC 20362-5100

Curtis Ward
Defense Mapping Agency
8613 Lee Hwy.
Fairfax, VA 22031-2138

LCDR Jeff Wieringa
Naval Air Systems Command
Code 546D1G
Naval Engineering Logistics Office
Washington, DC 20361-1010

Dr. Jerome Williams
U.S. Naval Academy
Oceanography Department
Annapolis, MD 21402

Dr. Robert Winokur
Oceanographer of the Navy
OP-096
34th and Massachusetts Ave., NW
Washington, DC 20392-1800

REPORT DOCUMENTATION PAGE

Form Approved
OBM No. 0704-0188

1. Agency Use Only *(Leave blank).*

2. Report Date.
May 1992

3. Report Type and Dates Covered.
Final

4. Title and Subtitle.
Mapping, Charting, and Geodesy Division
Abstracts of Publications, Presentations, and Transitions 1991

5. Funding Numbers.
Program Element No. 0602435N, 0603704N, 0601152N, 0602435N
Project No. RM35G84, RM35G85,
Task No. 03208, 300, 0G0
Accession No. DN256002, DN255031 DN394459, DN257086
Work Unit No. 13500A, 13511C

6. Author(s).
Michael M. Harris and Janice M. Garner

7. Performing Organization Name(s) and Address(es).
Naval Oceanographic and Atmospheric Research Laboratory
Ocean Science Directorate
Stennis Space Center, MS 39529-5004

8. Performing Organization Report Number.
ADPUB 002:92

9. Sponsoring/Monitoring Agency Name(s) and Address(es).
Office of Naval Research
800 North Quincy St., ONR Code 120M
Arlington, VA 22217-5000

Oceanographer of the Navy
Chief of Naval Operations
U.S. Naval Observatory
34th & Mass. Ave., NW
Washington, DC 20390-1800

10. Sponsoring/Monitoring Agency Report Number.
ADPUB 002:92

11. Supplementary Notes.

12a. Distribution/Availability Statement.
Approved for public release; distribution is unlimited.

12b. Distribution Code.

13. Abstract *(Maximum 200 words).*

This document presents abstracts of the 1991 publications and presentations of the Mapping, Charting, and Geodesy Division, Naval Oceanographic and Atmospheric Research Laboratory, Stennis Space Center, MS.

14. Subject Terms.
requirements, mapping, hydrography, optical properties, remote sensing, reverberation, bathymetry, arc digitized raster graphic, world vector shoreline

15. Number of Pages.
79

16. Price Code.

17. Security Classification of Report.
Unclassified

18. Security Classification of This Page.
Unclassified

19. Security Classification of Abstract.
Unclassified

20. Limitation of Abstract.
SAR